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An Analysis of Minnesota's Fifth Forest Resources Inventory, 1990

Earl C. Leatherberry, John S. Spencer, Jr., Thomas L. Schmidt, and Michael R. Carroll

North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
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This report includes the most commonly used Forest Inventory and Analysis statistics. Additional forest resource data can be provided to interested users. Persons requesting additional information from the raw inventory data are expected to pay the retrieval costs. These costs range from less than $100 for a relatively simple request to $2,000 for a complex retrieval involving the services of a Forest Inventory and Analysis computer programmer. Requests will be filled so as to minimize the impact on the Forest Inventory and Analysis Work Unit.

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FOREWORD

The fifth inventory of Minnesota was directed by Neal Kingsley, Forest Inventory and Analysis (FIA) Program Manager. David Heinzen, supervisor for the Minnesota Department of Natural Resource's (DNR) Resource Assessment Analysis Program, was responsible for overseeing all DNR personnel and contract field crews. Jerold Hahn and Mark Hansen were responsible for inventory design. Jerry Ostrom supervised the FIA field crews that were responsible for collecting field data in the Central Hardwood and Prairie Units and in part of Itasca County. Steve Flackey of the Minnesota DNR supervised the field crews that collected data in the Aspen-Birch and Northern Pine Units. Beth Collins supervised FIA's photo interpretation staff; George Deegan of the Minnesota DNR was responsible for supervising State photo interpreters.

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Training provided by Minnesota DNR disease and insect specialists increased the accuracy of tree class determination. These classifications now more accurately reflect the utilization of aspen and several other species. Training of field crews was done by Michael Albers, Jana Albers, and Ed Hayes. Tom Eiber and Alan Jones were responsible for the development of standardized disease and damage codes. Olin Phillips, Cooperative Forest Management Supervisor, established the cooperative framework.

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Pat Miles and Mark Hansen were responsible for generating area, volume, growth, and removals tables. Brad Smith and Ron Hackett collected and compiled data on timber product outputs and timber removals. Pat Murray and Jay Solomakos edited the data.

Mary Jean Hanson and Dan Goodman provided administrative and secretarial support. Computer support was provided by Gerhard Raile.

Forest Inventory and Analysis (FIA) is a continuing endeavor as mandated by the Renewable Resources Research Act of 1978. Prior inventories were mandated by the McSweeney-McNary Forest Research Act of 1928. The objective of FIA is to periodically inventory the Nation's forest land to determine its extent, condition, volume of timber, growth, and removals. Up-to-date resource information is essential to frame forest policies and programs. USDA Forest Service regional Experiment Stations are responsible for conducting these inventories and publishing summary reports for individual States. The North Central Forest Experiment Station is responsible for forest inventory and analysis in Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin.

Fieldwork for the fifth Minnesota forest inventory was begun in April 1986 and completed in February 1991. Reports of four previous inventories of Minnesota's timber resource are dated 1936, 1953, 1962, and 1977.

More accurate survey information was obtained during this survey than otherwise would have been feasible because of intensified field sampling. Such sampling was made possible through the cooperation and assistance of the Minnesota DNR. Data for the Aspen-Birch and Northern Pine Units were collected by contract crews hired and supervised by the Minnesota DNR. The DNR installed several hundred additional plots on National Forest land. These efforts increased the sampling intensity on National Forest land from a single intensity level to the triple intensity level typical of the rest of the State. Data for the Central Hardwood and Prairie Units were collected by FIA. To aid in determining current timber removals, the Minnesota DNR also surveyed primary wood-using plants in the State.

Aerial photos used in the forest inventory were purchased by the State from the U.S. Geological Survey. This photography was from the National High Altitude Photography program (NHAP). In addition, the Minnesota DNR provided 35mm true color prints at a scale of 1:15,840 of all of the 1977 plot locations for disturbance detection.

HIGHLIGHTS

NOTE: *Comparison of data from new forest inventories with data from earlier inventories indicate trends in forest resources. However, comparisons are only valid if the procedures used in the two inventories are similar. Because of our ongoing efforts to improve the efficiency and reliability of the inventory, several changes in procedures and definitions have been made since 1977. Some of these changes make it inappropriate to directly compare the 1990 data with those published for 1977. Therefore, data from the 1977 inventory were reprocessed using the 1990 procedures and were published in part in the State statistical report (Miles et al. 1995). Please refer to the Appendix section labeled "Comparing Minnesota's Fifth Inventory with the Fourth Inventory" for more details. Also, data published in the four Minnesota Unit reports (Murray, 1991, Kingsley 1991, Leatherberry 1991, Roussopoulos 1992) may not add to statewide totals reported here due to minor adjustments.*

AREA

- Minnesota's forest land area increased from 16.5 million acres in 1977 to 16.7 million acres in 1990, an increase of about 1 percent.
- Forest land is concentrated in the Aspen-Birch and Northern Pine Survey Units, where Lake and Cook Counties are more than 90 percent forested.
- Most of the increase in forest land area occurred in southern Minnesota in the Central Hardwood and Prairie Survey Units, where forest land area increased by 339 million acres.
- Timberland area increased from 13.6 million acres in 1977 to 14.7 million acres in 1990. Much of the increase came from land that in 1977 was classified unproductive forest land and reclassified in 1990 as marginally productive timberland.
- Aspen forest type covers the largest timberland area in the State (5.1 million acres), followed by maple-basswood (1.4 million acres), black spruce and elm-ash-soft maple (1.3 million acres), respectively, and oak-hickory (1.2 million acres).
- Fifty-two percent of the State's timberland area is in public ownership. State government holds 21 percent, county and municipal governments hold 17 percent, and the Federal Government holds 14 percent of Minnesota's timberland. Publicly owned timberland is concentrated in the Aspen-Birch and Northern Pine Survey Units, where 9 of every 10 acres of publicly owned timberland is located.
- Nonindustrial private owners own 40 percent (5.9 million acres) of the State's timberland area. Among nonindustrial owners, individuals control 36 percent of the State's timberland area.
- Stand-size classes are nearly evenly distributed. Poletimber stands are predominant, extending over 36 percent of the State's timberland area, followed by sawtimber stands that occupy 33 percent of the total area and sapling-seedling stands that occupy 30 percent of the timberland area.

NUMBER OF TREES

- The number of growing-stock trees 5.0 inches in diameter and larger rose from 1.9 billion to 2.1 billion from 1977 to 1990, an increase of 10 percent.

TIMBER VOLUME

- The volume of growing stock increased from 12.4 to 15.1 billion cubic feet between 1977 and 1990, a 22-percent gain.
- Sawtimber volume increased from 24.4 to 34.9 billion board feet between inventories, a 43-percent gain.
- St. Louis County contains the largest growing-stock volume (2,506 million cubic feet), followed by Itasca County (1,451), Koochiching County (1,255), Cass County (1,067), Beltrami County (921), and Lake County (840).
- The aspens contained the largest volume of any species in 1990—27 percent of the total growing-stock volume.

- Aspen growing-stock volume rose from 3,452 to 4,098 million cubic feet between 1977 and 1990, a 19-percent increase.

- Public agencies administer 51 percent of the State's growing-stock volume, and private owners account for 49 percent. Private individuals hold 37 percent of the total.

- In 1990 there was 2.2 billion cubic feet in non-growing-stock volume—rough, rotten, short-log, and salvable dead trees.

- Average volume per acre of growing stock was 1,028 cubic feet (13.0 cords) in 1990, compared to 909 cubic feet (11.5 cords) in 1977.

GROWTH AND MORTALITY

- The volume of net annual growth of growing stock in 1989 (current growth) was 440 million cubic feet, 40 percent greater than the 1976 growth of 315 million cubic feet.

- The net growth rate for growing stock was 2.9 percent of inventory in 1989, up from 2.5 percent in 1976.

- Growing-stock growth per acre amounted to 29.9 cubic feet in 1989, compared to 23.1 cubic feet in 1976.

- Average net annual growth during the period 1977 to 1989 (periodic growth) was 370 million cubic feet.

- Annual mortality of growing stock increased from 169 million cubic feet in 1976 to 208 million cubic feet in 1989, a 23-percent gain.

- Diseases caused 57 percent of the growing-stock mortality volume.

REMOVALS

- Annual timber removals from growing stock increased from 194 million cubic feet in 1976 to 261 million cubic feet in 1988, a 35-percent increase.

- Annual sawtimber removals surged from 460 million board feet in 1976 to 777 million board feet in 1988, a 69-percent gain.

- Annual timber removals from growing stock averaged 210 million cubic feet during the period 1977 to 1989.

- Average annual net growth of growing stock (370 million cubic feet) exceeded average annual removals (210 million cubic feet) by 77 percent during the period 1977 to 1989.

- Annual net growth of growing stock in 1989 (440 million cubic feet) exceeded annual timber removals in 1988 (261 million cubic feet) by 69 percent.

BIOMASS

- Total biomass of all live trees at least 1 inch d.b.h. on timberland amounted to 885 million green tons in 1990, an average of 60 green tons per acre.

PROJECTIONS

- The low removals option projection shows growing-stock inventory rising from 15.1 billion cubic feet in 1990 to 20.5 billion cubic feet in 2020, a 36-percent gain. Growth exceeds removals throughout the projection period.

- The high removals option projection shows growing-stock inventory increasing from 15.1 billion cubic feet in 1990 to 17.9 billion cubic feet in 2020, a 19-percent gain. Growth remains greater than removals, but the two converge throughout the projection period.

ECONOMIC BENEFITS OF FOREST PRODUCTS INDUSTRY

- In 1991, the forest products industry had annual shipments of $6 billion.

- Sixty-two percent of the primary wood processors (sawmills) are located in the Aspen-Birch and Northern Pine Survey Units.

- Secondary wood processors tend to be located in the seven-county Twin Cities Metropolitan Area.

NONTIMBER BENEFITS OF FOREST

- In 1990, Minnesota had more than 105,000 acres of planted windbreaks and more than 101,000 acres of natural wooded strips that provided significant soil erosion prevention benefits and made important contributions to improving water quality.

- Minnesota's forests provided critical habitat for wildlife species that are included on either Federal or State lists of endangered or threatened species. Examples of forest-dependent wildlife species that are of special concern include red-shouldered hawk, gray wolf, pine marten, wood turtle, and bald eagle.

- The ruffed grouse is Minnesota's most abundant game bird, with annual harvests of over a million birds in peak years by up to 151,000 hunters. These birds provide many benefits, ranging from the joy and excitement of seeing their beautiful plumage to the economic inputs provided by hunters.

- Minnesota's forests provide many products that are not normally associated with forest industries. Examples of special forest products include evergreen wreaths and similar products (about $10 million of products sold each year); maple syrup (more than 33,000 gallons produced each year); and tamarack, white spruce, and pine cones used in both the potpourri and cone wreath industries.

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An Analysis of Minnesota's Fifth Forest Resources Inventory, 1990

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INTRODUCTION

This report presents an analysis of the fifth Minnesota forest resources inventory, conducted by the U.S. Department of Agriculture, Forest Service, in cooperation with the Minnesota Department of Natural Resources, Division of Forestry. The inventory was completed in 1990. Previous inventories were conducted in 1936 (Cunningham and Moser 1938), 1953 (Cunningham *et al.* 1958), 1962 (Stone 1966), and 1977 (Jakes 1980, Spencer 1982). This analysis provides a historical overview of how Minnesota's forest land[1] base has changed over the years and discusses some of the factors that influenced the change. It describes the extent and condition of Minnesota's timberland resources as of 1990, in terms of timberland area, timber volume, growth, mortality, removals, and the economic importance of wood-using industries to the State's economy. Also, it discusses the importance of forests for the nontimber benefits they provide. And it provides two 30-year projections of the State's growing-stock inventory.

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MINNESOTA'S FOREST LAND: A HISTORICAL OVERVIEW

Before the influx of large numbers of European settlers into what is now Minnesota, about 60 percent (31.5 million acres) of the land area was forest (Cunningham *et al.* 1958). Forest prevailed in what is now the northeast quarter of the State, where towering pines dominated the landscape. In the northwestern counties was a large, wet area in which open bogs and brush prairie intermingled with stands of spruce and tamarack (USDA Forest Service 1937). In the south central region of the State, the forest was dominated by mixed stands of hardwood trees, mostly sugar maple, elm, ash, basswood, and red oak (USDA Forest Service 1937). The land was so heavily forested that early European explorers and settlers called the area the "Big Woods." To the southeast, on the unglaciated hills and in river valleys, stands of oaks were dominant, mixed with species such as walnut, butternut, and honey locust. To the west and south, tallgrass prairie was the dominant vegetation, and trees, especially cottonwoods, box elder, green ash, silver maple and elm, were found along the river bottoms. In the east, the prairie was fringed with a savanna-like area supporting groves of aspen and scrubby bur oak, intermingled with grassland (USDA Forest Service 1937). However, most of the tree species occurred to some extent in all regions. Marschner's 1930 map of Minnesota's original vegetation, compiled from information in the U.S.

[1] *See Definition of Terms in the Appendix for this and other terms used in the report.*

General Land Office Survey Notes, is a remarkably good generalization of the character of Minnesota's vegetation just before land settlement by Europeans (Heinselman 1974).

With the coming of European settlers vast areas of forest were cut to provide lumber and railroad ties to build cities and railroad lines. Other forested areas were cleared for agriculture. Lumber mills were established at Stillwater, Minneapolis, Red Wing, Winona, and other river towns. By 1850, lumbering was a leading industry in Minnesota; by 1899, Minneapolis sawmills had a yearly output of 678 million board feet and claimed to be the world's largest primary lumber market (USDA Forest Service 1937). In 1896, to feed the mills and to accommodate the expanding population, large tracts of timber and other land in the northern part of the State were opened to settlement. Lumber production in Minnesota peaked in 1905 (Waters 1977).

By the start of the 20th century, the original forest had been reduced by more than half, to an estimated 12 million acres (Cunningham and Moser 1938). Much of the cut-over land was left covered with stumps and logging slash. Fires fueled by the dried slash periodically roared across the landscape. The "Great" Hinckley forest fire of 1894 engulfed 160,000 acres and took the lives of 413 people. The Cloquet-Moose Lake fire of 1918 burned 200,000 acres and killed 483 people (Swenson 1979).

The diminished forest land base, along with periodic fires and the general lack of forest management, led the State and Federal Governments to enact laws and establish regulations that fostered forest management, including protection, reforestation, and conservation. For instance, in 1911 the Minnesota legislature enacted laws that established a board of nine members to administer fire, slash control, and reforestation programs. The board preceded the Department of Conservation (presently the Department of Natural Resources), which was established in 1925 (Minnesota Department of Natural Resources 1971). Also, several significant steps were taken to preserve portions of the State's forest. For example, Itasca State Park was established in 1891. The Chippewa and Superior National Forests were established in 1908 and 1909, respectively. And, in 1925 a "primitive area" was established within the Superior National Forest that restricted logging and set aside areas to be preserved in their pristine state.

The effects of logging and wildfire dramatically changed the composition of the forest. In the northeast and north-central portions of Minnesota, the original forest cover of mostly white and red pines did not return after logging or fire because those species reproduce primarily from seeds and few seed trees remained. Also, much of this area was cleared in attempts to promote agriculture. However, aspen, a pioneer species, was able to expand into new areas. Jack pine also expanded in some areas. Although fire easily kills jack pine, it also contributes to the reestablishment of the species by releasing seeds from the serotinous cones. In much of northern Minnesota, the new forest was composed mostly of species considered to be "weed trees"—aspen, jack pine, and birch. In central Minnesota, hardwood species remained and in some areas expanded as fire control allowed for extension of forest acreage. In the southeast, the plowing of marginal lands on upland slopes and pasturing on hillsides reduced much of the forest land to eroded wasteland (USDA Forest Service 1937). The forest that remained was mostly of low quality oaks and other hardwoods.

The Great Depression had the effect of increasing forest land area in Minnesota. Much of the cut-over and burned-over land sold to prospective farmers was not suited for crop production, and owners had a hard time earning a living (Schoone-Jongen 1993). Widespread tax forfeiture among landowners occurred. Some tax-forfeited land reverted to forest or was planted to forest. The Civilian Conservation Corps, designed to employ and teach young men job skills, planted many areas back to forest. In 1936, the USDA Forest Service published the results of the first statewide comprehensive inventory of Minnesota's forest land (fig. 1). The 1936 inventory revealed that forest land area in Minnesota totaled about 19.6 million acres, up from a low of about 12 million acres at the turn of the century. However, only 1.6 million acres of sawtimber-size stands remained in the State, most in the northeast. Aspen, scrub oak, grass, and brush covered nearly half of the total forest area in the State (Cunningham and Moser 1938). In the area that corresponds to the Central Hardwoods and Prairie Units (fig. 3), 90 percent of the

Figure 1.—*The 1936 forest inventory of Minnesota found that many stands contained small sawtimber trees of poor form and vigor.*

sawtimber volume had been removed from the land (USDA Forest Service 1937).

Between 1936 and 1953, forest land declined by only an estimated 300 thousand acres. At midcentury, Minnesota had an estimated 19.3 million acres of forest land (Cunningham *et al.* 1958). Better management, improved protection, and the natural reversion to forest helped maintain a relatively stable forest land base. Also, the loss of forest land for agriculture and other uses was offset by reversion of submarginal farms to forest (Cunningham *et al.* 1958). The forest was mostly made up of hardwood species—aspens and mixed hardwoods. Softwoods, found primarily in the north, were mostly swamp conifers—principally black spruce, tamarack and northern white-cedar. Between 1936 and 1953, the stocking level of hardwoods improved, but that of softwoods declined, in part due to heavy cutting during World War II.

The 1962 inventory revealed a forest land base of 19.1 million acres, a decline of 200 thousand acres since the 1953 inventory. The decline was due primarily to urbanization, new highway and utility rights-of-way, and other land clearing (Stone 1966). The most significant shift in forest area between the 1953 and 1962 inventories was the sharp downturn in nonstocked acreage. Almost 2 million acres were restocked through reforestation programs and natural regeneration. About half a million of the newly stocked acres supported softwoods (Stone 1966).

Between the 1962 and 1977 inventories, Minnesota's forest land base declined by about 2.5 million acres. More than 1 million acres of timberland was converted to nonforest uses. The greatest loss of forest area occurred in the more heavily urban and agricultural south-central and western portions of the State. Between the 1962 and 1977 inventories, 406 thousand acres of timberland were converted to urban and other related uses (Jakes 1980). With creation of the Voyageurs National Park and expansion of the Boundary Waters Canoe Area Wilderness, 673 thousand acres of timberland were converted to reserved forest land between inventories. The 1970's were also a period of maximum crop production as farmers plowed "from fencerow to fencerow." Area in cropland increased to record levels (Minnesota State Planning Agency 1988). Agricultural expansion resulted in the conversion of 483 thousand acres of timberland to cropland and pasture land between 1962 and 1977 (Jakes 1980).

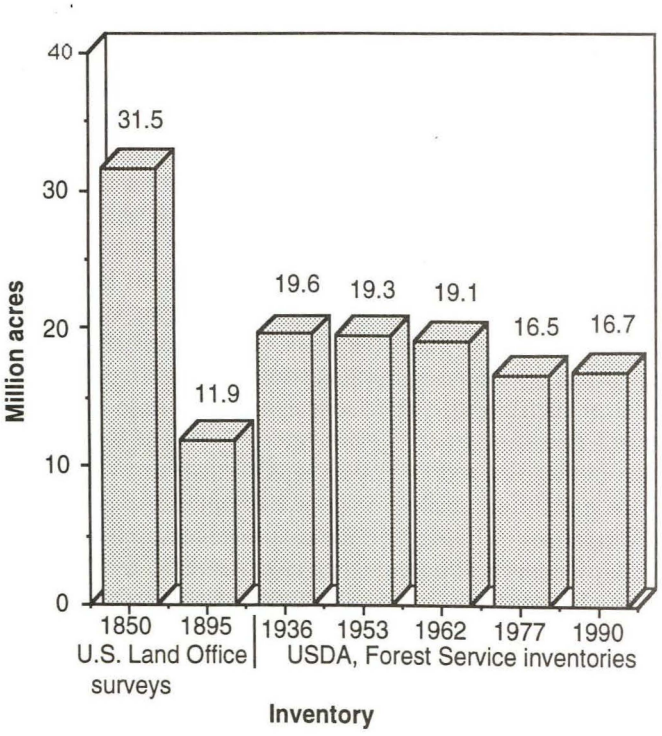

Figure 2.—*Change in forest land area, Minnesota, 1850-1990. (Note only the acreage figure for 1977 was adjusted to 1990 to account for differences in survey procedures and definitions.)*

Over the years, the forest land base in Minnesota changed significantly in composition and area. Figure 2 depicts the magnitude of spatial changes in Minnesota's forest land from 1850 to 1990. The most profound change was the loss of nearly half the forest land base from 1850 to 1895. However, reforestation, fire protection and prevention, better forest management, and public concern resulted in the recovery and subsequent stabilization of the forest land area, which continues today.

RECENT CHANGES IN FOREST LAND AREA

Forest Land Increases Slightly Between 1977 and 1990

Forest land is separated into three components—timberland, reserved forest land, and other forest land (see Definition of Terms in Appendix). Between the 1977 and 1990 inventories, forest land area in Minnesota increased from 16.5[2] million to 16.7 million acres, a difference of 144 thousand acres or about 1 percent. Although small, this gain represents the first increase in forest land area since the reforestation efforts of the late 1920's and 1930's. Minnesota joins other Midwestern States in reporting increases in forest land area between their most recent inventories. A number of factors contributed to the increase in forest land. The overall slowing of growth in the agricultural sector in the 1980's resulted in some marginal agricultural land reverting to forest, particularly in southern Minnesota. Also, some land classified as wooded pasture in 1977 was reclassified as forest land because there was no evidence of grazing in 1990. Between inventories, wooded pasture land declined by 25 percent (33 thousand acres), most of that moving to the forest category. Also, a small proportion of the increase in forest land can be attributed to government programs that take highly erodible lands out of agricultural production. Under the Reinvest in Minnesota (RIM) Reserve Program, created in 1986 by the State legislature, land is taken out of production and reserved, specifically to enhance wildlife habitat. The Conservation Reserve Program (CRP), created in 1985 by the Federal Government, removes erosion-prone cropland from crop production. As of mid-1988, more than 1.5 million acres of land had been retired through CRP, and about 21,000 acres were enrolled in the RIM Reserve Program (Minnesota State Planning Agency 1988). Some of the acres taken out of crop production through these programs converted to woody vegetation.

Forest Land Concentrated in Northern Minnesota

Minnesota is divided along county boundaries into four forest survey units, based largely on topography and other physiographic considerations (fig. 3). The Aspen-Birch Unit is the most heavily forested region of the State. Lake and Cook Counties are more than 90 percent forested, and the other counties in the Unit are at least 60 percent forested. The Aspen-Birch Unit contains 44 percent (7.4 million acres) of the State's forest land, followed by the Northern Pine Unit with 38 percent (6.3 million acres), the Central Hardwood Unit with 14 percent (2.3 million acres), and the Prairie Unit with the remaining 4 percent (657 thousand acres). Forest land accounts for 85 percent of the land area in the Aspen-Birch Unit, 57 percent in the Northern Pine Unit, 20 percent in the Central Hardwood Unit, and only 3 percent in the Prairie Unit.

Southern Minnesota Gains Forest Land

Between inventories, the Central Hardwood and Prairie Units had an increase in forest land area of 12 percent (254.9 thousand acres) and 15 percent (83.9 thousand acres), respectively. In the Aspen-Birch Unit, forest land area remained practically unchanged, increasing by less than 1 percent (41 thousand acres). The Northern Pine Unit lost forest land, with a decline of 236.2 thousand acres. The decline in the Northern Pine Unit resulted partly from the 53 percent (382.4 thousand acres) drop in land classed as other forest land (see Definition of Terms in the Appendix). Although some of that land may have been reclassified to timberland, part of it went into nonforest uses, such as road or utility rights-of-way, home and industrial development, and recreation development. As mentioned previously, the increase in forest land in southern Minnesota is due largely to the farm "crisis" of the 1980's, which resulted in less land being cultivated or pastured.

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[2] *Adjusted from the published 1977 area of 16.7 million acres to account for differences in survey procedures and definitions, particularly in aerial photo procedures that more accurately distinguished between forest and nonforest land.*

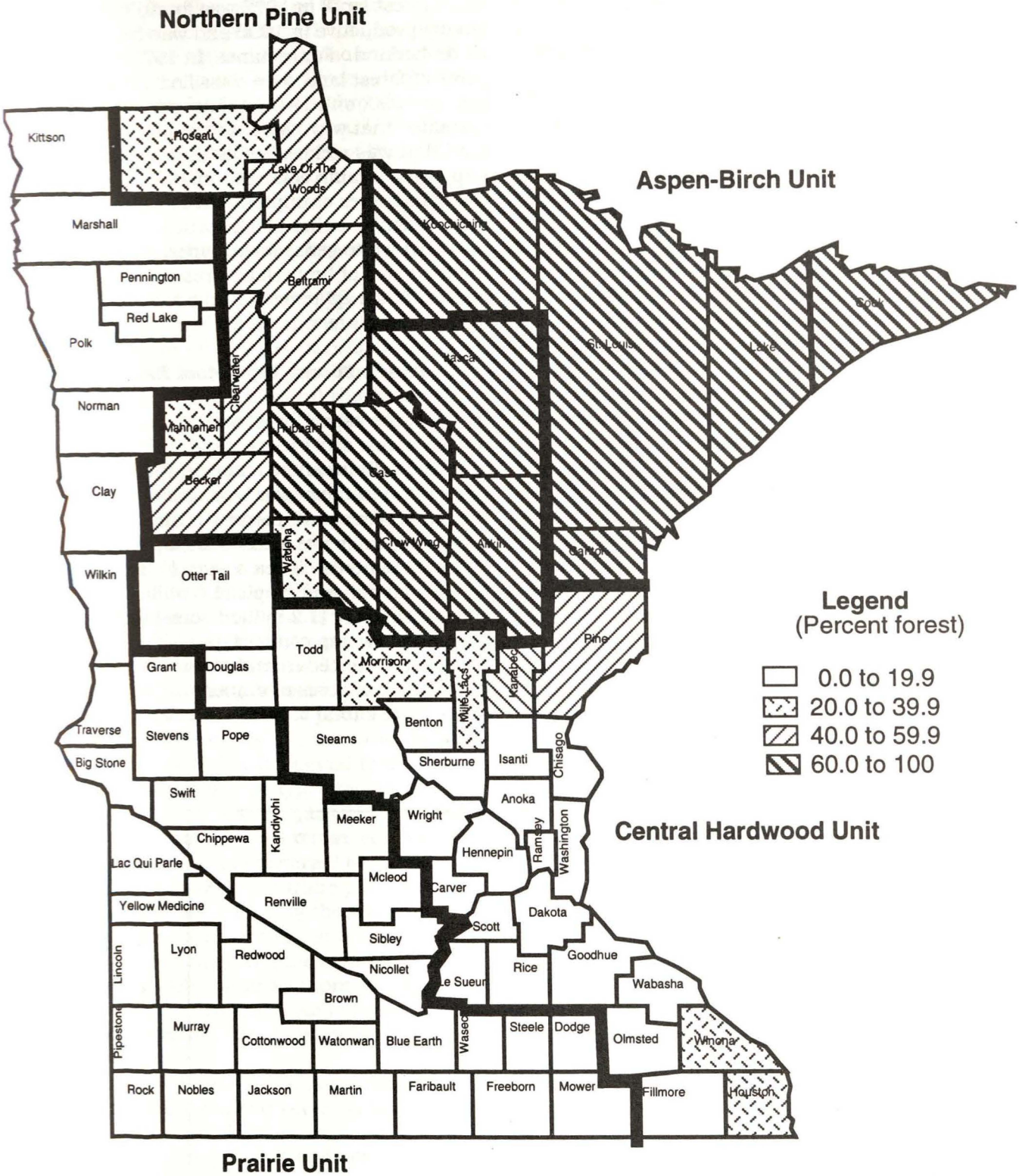

Figure 3.—*Minnesota's four Forest Survey Units and percent of forest cover, 1990.*

Reserved Forest Land Increases

In 1990, there were 1.1 million acres of reserved forest land in Minnesota. Between inventories, reserved forest land increased by 94,500 acres. Ninety percent (1 million acres) of the reserved forest land is located in the Aspen-Birch Unit, much of it in the Boundary Waters Canoe Area Wilderness and Voyageurs National Park. However, most of the increase in reserved forest land occurred in the Central Hardwood Unit, which had only 14 thousand acres of such land in 1977, but 70 thousand acres in 1990. The increase of reserved forest land in the Central Hardwood Unit is mostly due to expansions of county park preserve systems in the Minneapolis/St. Paul Metropolitan Area and to the designation of the Lower St. Croix River as a National Wild and Scenic Riverway.

TIMBERLAND AREA

Timberland Area Increases Eight Percent

Between 1977 and 1990, timberland area in Minnesota increased from 13.6 million to 14.7 million acres, an 8-percent gain. Much of the 1.1 million-acre increase can be attributed to the fact that some unproductive forest land (defined as other forest land) in 1977 was found to be marginally productive in 1990 and was reclassified as timberland. For instance, in 1977, 1.9 million acres of forest land were classified unproductive, but, in 1990, only 840.5 thousand acres were classified that way. Most unproductive forest land that was reclassified as timberland in 1990 supported swamp conifers. In 1990, about 493 thousand acres of unproductive forest land were reclassified as either black spruce, tamarack, or northern white-cedar forest types. The 14.7 million acres of timberland present in 1990 accounted for 88 percent of the total forest land area in the State.

Aspen Forest Type Most Extensive

In 1990, the aspen forest type accounted for 5.1 million acres, or 34 percent of the State's timberland area. Between inventories, the area of timberland in the aspen type declined by 103.2 thousand acres, or 2 percent. Other types occupying extensive area were maple-basswood (1.4 million acres), black spruce (1.3 million acres), elm-ash-soft maple (1.3 million acres), and oak-hickory (1.2 million acres) (fig. 4). As a group, the swamp conifer types—black spruce, northern white-cedar, and tamarack—accounted for 2.7 million acres of timberland, or 18 percent of the State's total area of timberland.

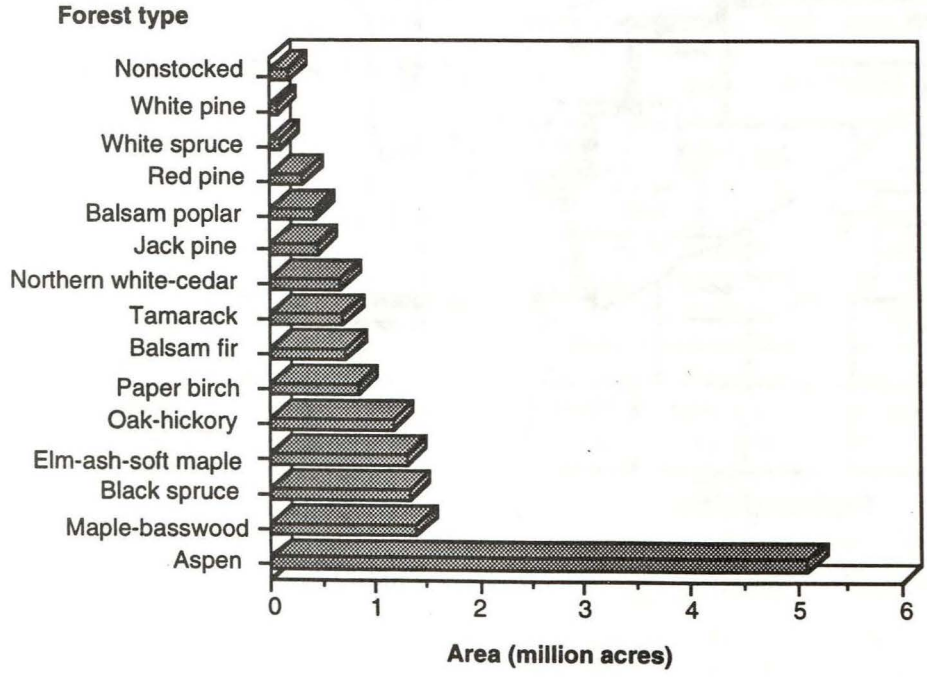

Figure 4.—*Area of timberland by forest type, Minnesota, 1990.*

Virtually all (4.3 million acres or 97 percent) of the area of softwood types is in the Aspen-Birch and Northern Pine Units, which also contain 85 percent of the area in the aspen type. Hardwood types dominate in the Central Hardwood and Prairie Units. The Central Hardwood Unit contains 40 percent (1.5 million acres) of the State's timberland area in the oak-hickory, elm-ash-soft maple, and maple-basswood types.

Changing Forest Types

The spatial distribution of forest types in Minnesota is largely defined by the three major biomes found in the State—the northern coniferous forest (Aspen-Birch and Northern Pine Units), the eastern deciduous forest (Central Hardwood Unit), and the tallgrass prairie (Prairie Unit). However, the forest is in a continual state of flux, and forest composition has shifted rather dramatically over time. For instance, hardwood forest types, especially aspen, have replaced softwood types on many sites. As alluded to earlier, the presettlement softwood forest occupied an estimated 18 million acres—57 percent of the State's forested land. In 1990, softwood types occupied only 4.4 million acres (30 percent) of Minnesota's timberland area. Table A shows land classification changes from 1977 to 1990, based on the remeasurement of permanent sample plots by field crews. To use table A—for example, to find out what happened to the 451 thousand acres of jack pine type present in 1977—simply read across the jack pine row and find that 345 thousand acres remained as jack pine, 33 thousand acres converted to red pine, 1 thousand acres converted to white pine, and so on. To determine the source of the 457 thousand acres of jack pine present in the 1990 survey, read down the jack pine column. Of these acres, 345 thousand were previously jack pine, 2 thousand converted from red pine, nearly 8 thousand converted from balsam fir, and so on.

The black spruce type had the largest increase in area, gaining 285 thousand acres—a 28-percent increase. The tamarack type increased by 214 thousand acres or a gain of 44 percent. As mentioned above, much of the increase in area for those types can be attributed to the fact that some of the area classified as other forest land (unproductive forest) in 1977 was found to be marginally productive and was reclassified as timberland in 1990 (table A).

The paper birch and balsam poplar types declined significantly in area. Area in paper birch type declined by 164 thousand acres (17 percent), and area in balsam poplar type declined by 122.9 thousand acres (22 percent). Much of the loss of paper birch forest type in Minnesota is related to the advanced age of many paper birch stands. Paper birch is a short-lived species that matures in about 60 to 70 years. In 1990, 41 percent of the paper birch area in Minnesota was in stands older than 61 years of age. Many of the mature and overmature stands were attacked by the bronze birch borer *(Agrilus anxius)*, and forest tent caterpillar *(Malacosoma disstria)*, which, along with periods of drought, contributed to the decrease in area of this type. As the paper birch forest aged and was weakened by insect attacks, shade-tolerant species growing in the understory emerged as the dominant species. For instance, between 1977 and 1990, 31 thousand acres converted to the elm-ash-soft maple type, 48 thousand acres converted to the maple-basswood type, and 37 thousand acres converted to the balsam fir type. Another 184 thousand acres of paper birch converted to the aspen type.

The decline in balsam poplar type between inventories was due largely to conversion to the aspen and elm-ash-soft maple types, and to nonforest land. It should be noted that forest type is a classification of land based on the species forming a plurality of live tree stocking. Because forest types are often a mixture of species, the cover type may change as a result of only a slight change in the mix of species.

As noted earlier, the area of aspen type declined by 103 thousand acres (2 percent) between inventories (table A). Eighty-one percent of the 1977 area in the aspen type remained aspen in 1990 (4.2 million acres). In addition to 184 thousand acres of paper birch type and 94 thousand acres of balsam poplar type that converted to aspen, 92 thousand acres of balsam fir type and 296 thousand acres from nontimberland converted to aspen, along with smaller acreages from other forest types. The additions helped to mitigate the 229 thousand acres of aspen type that converted to mixed hardwood types between inventories, as mature and overmature aspen stands deteriorated and converted to the shade-tolerant species that had been in the understory.

Table A. Forest land classification changes in Minnesota, 1977-1990

(In thousand acres)

1977 land classification	1977 Area[2]	1990 land classification[1]																		
		Timberland - forest type																		
		Jack pine	Red pine	White pine	Balsam fir	White spruce	Black spruce	North. white-cedar	Tamarack	Oak-hickory	Elm-ash-soft maple	Maple-bass-wood	Aspen	Paper birch	Balsam poplar	Non-stocked	Other forest land	Res. forest land	Non-forest land	Census water
Timberland																				
Jack pine	450.8	344.7	33.0	1.4	2.8	0.8	10.5	-	-	8.3	3.2	4.7	29.9	2.2	1.2	1.7	-	-	6.5	-
Red pine	243.8	2.3	186.0	-	1.5	-	-	-	1.8	-	-	1.5	8.4	1.6	-	1.8	-	-	39.0	-
White pine	68.3	-	5.8	41.1	2.2	-	-	-	-	-	-	2.5	10.4	-	-	-	-	6.1	-	-
Balsam fir	820.0	7.8	19.1	4.5	494.8	9.8	31.4	36.9	10.5	-	16.0	12.9	91.9	37.1	5.4	7.0	2.3	3.1	16.3	3.0
White spruce	62.9	-	-	1.9	3.7	47.7	-	1.9	-	-	-	-	4.7	3.2	-	-	-	-	-	-
Black spruce	1,037.0	11.2	1.0	-	24.2	0.8	883.0	13.3	48.6	-	7.4	-	29.4	5.5	-	-	-	5.1	7.3	1.6
N.white-cedar	546.0	-	2.4	-	18.9	-	1.5	487.1	13.1	-	7.1	1.8	3.8	2.3	1.3	-	3.0	-	3.4	1.5
Tamarack	491.1	-	-	-	6.6	-	20.2	6.0	435.3	-	4.2	-	1.1	1.1	1.9	3.6	2.8	-	8.8	-
Oak-hickory	928.7	4.9	1.2	-	1.9	-	-	-	-	801.1	3.6	47.3	29.6	2.4	-	-	-	-	37.1	-
Elm-ash-soft maple	1,006.8	-	-	-	8.2	-	1.8	17.7	2.3	6.9	805.3	53.6	37.6	6.8	11.1	4.9	3.5	-	46.1	1.5
Maple-basswood	1,202.4	6.3	8.4	4.3	3.8	3.6	1.9	-	-	52.8	63.1	935.6	49.3	7.4	4.5	-	-	-	61.9	-
Aspen	5,158.2	25.4	48.0	1.6	76.4	28.7	34.6	14.0	10.4	106.2	93.9	135.1	4,168.7	117.5	41.1	17.7	4.5	48.6	186.2	2.0
Paper birch	991.2	6.1	11.0	3.3	36.6	10.3	1.6	-	7.2	17.7	31.1	48.2	184.4	597.3	5.0	2.2	1.2	7.9	19.8	1.6
Balsam poplar	547.6	1.6	1.1	-	8.8	-	-	5.3	3.7	-	48.8	7.9	94.4	12.8	298.4	15.8	2.5	-	46.9	-
Nonstocked	58.3	4.5	4.4	-	-	0.9	3.2	-	8.9	-	4.9	-	15.5	-	1.4	7.5	-	-	7.1	-
Non-timberland																				
Other forest land	1,901.4	3.6	4.3	-	27.4	2.6	289.2	86.6	116.9	61.7	38.2	20.3	50.7	-	11.0	9.2	777.5	42.3	360.7	-
Reserved forest land	1,022.9	-	11.5	-	-	-	-	-	-	1.4	-	0.7	11.2	-	-	-	17.6	980.5	-	-
Nonforest land	34,207.4	38.9	38.1	5.6	15.0	5.9	41.1	11.7	46.4	109.5	159.9	119.8	231.2	30.0	42.4	47.3	25.6	19.2	33,606.9	-
Census water	3,058.7	-	-	-	-	-	2.1	1.1	-	-	3.2	1.2	2.8	-	-	-	-	4.6	107.3	2,936.4
All land classes	53,803.5	457.3	375.3	63.7	732.8	111.1	1,322.1	681.6	705.1	1,165.6	1,289.9	1,393.1	5,055.0	827.2	424.7	118.7	840.5	1,117.4	34,015.3	3,107.1
Percent net change (1977-1990)		1.4	56.0	-6.7	-10.6	76.6	27.5	24.8	43.6	25.5	28.1	15.9	-2.0	-16.5	-22.4	103.6	-55.8	14.2	-.6	1.6

[1] Read across rows to determine dispersion of 1977 classes to 1990 classes. Read down columns to determine origin of 1990 classes.

[2] Total land area adjusted to conform to 1980 census figures.

Between 1977 and 1990, the oak-hickory and elm-ash-soft maple forest types increased by 237 and 283 thousand acres, respectively. Also, the maple-basswood type increased by 191 thousand acres. Several factors contributed to the increased area in those hardwood types. First, they gained area at the expense of forest types such as paper birch, balsam poplar, and aspen, which are composed mostly of pioneer species. As the relatively short-lived early successional species died or were harvested, they were replaced by the more shade-tolerant hardwood species. Also, when stands of shade-intolerant species are harvested, the tolerant understory species are released and the stand converts to the more tolerant species. Second, as grazing by domestic livestock on wooded pasture land decreased, the stand recovered, stocking levels improved, and seedlings were better able to become established. Table A shows that a significant acreage of nonforest land, much of it pasture land, converted to hardwood forest types between inventories.

The Majority of Timberland Publicly Owned

Fifty-two percent (7.6 million acres) of the State's timberland area is in public ownership (fig. 5). State agencies hold 21 percent (3.1 million acres), county and municipal governments hold 17 percent (2.5 million acres), and the Federal Government holds 14 percent (2.0 million acres), most of that (1.8 million acres) in the Superior and Chippewa National Forests. Publicly owned timberland is concentrated in the Aspen-Birch and Northern Pine Units. Two-thirds (3.9 million acres) of the timberland in the Aspen-Birch Unit is publicly owned. In the Northern Pine Unit, 54 percent (3.2 million acres) is publicly owned. The two northern Units contain 9 of every 10 acres of publicly owned timberland in the State.

The majority of the timberland that supports softwood forest types is publicly owned. For instance, 55 percent of the area of jack pine; 68 percent of red pine, white spruce, and balsam fir; and 75 percent of the swamp conifer types are publicly owned. Fifty-one percent of the aspen type area is publicly owned.

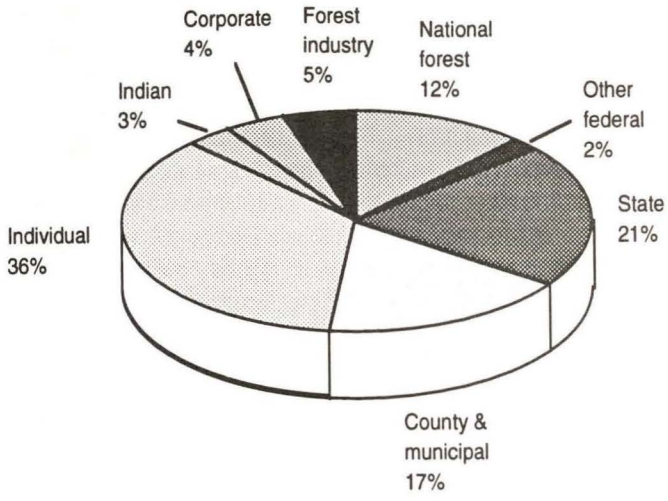

Figure 5.—*Timberland area by ownership class, Minnesota, 1990.*

Most Private Timberland in Small Parcels

Nonindustrial private owners (individuals and corporations other than forest industry) own 40 percent (5.9 million acres) of the State's timberland area. Among nonindustrial owners, individuals control the largest share of timberland, with 36 percent (5.3 million acres) of the State's total. Sixty-seven percent (3.6 million acres) of the timberland owned by individuals is in parcels smaller than 100 acres. Private corporations tend to hold timberland in larger tracts. For instance, 47 percent (291 thousand acres) of the timberland owned by private corporations is held in parcels larger than 2,500 acres. Private timberland owners are a diverse group of people and hard to categorize. See Carpenter *et al.* (1986) for a more detailed analysis of Minnesota's private landowners' attitudes and intentions about ownership, management, harvest, and recreational use of their timberland.

Timberland held in trust by the United States for tribes or individual American Indians totals only 483.8 thousand acres. Most (374 thousand acres) of these Indian timberlands are in the Northern Pine Unit.

Forest Industry Ownership Decreases Five Percent

Forest industries own 5 percent (751 thousand acres) of the State's timberland area. Between

inventories, the forest industry share of timberland declined by 5 percent (41 thousand acres). Practically all (99 percent) of the forest industry owned timberland is in the Aspen-Birch and Northern Pine Units. Forest industry holdings are concentrated in timberland that supports softwood types. Forest industry owns 12 percent of the white spruce type, followed by 11 percent of the jack pine and red pine types, 10 percent of the balsam fir type, and 9 percent of the white pine type. Five percent (273 thousand acres) of the timberland area in the aspen type is owned by forest industry. Eighty-six percent of the forest industry timberland is held in parcels larger than 5,000 acres.

Stand-Size Classes Evenly Distributed

The distribution of Minnesota's timberland area by stand-size class changed rather substantially between inventories (fig. 6). In 1977, poletimber stands extended over 6.9 million acres (51 percent) of the State's timberland area. In 1990, poletimber stands were still predominant, but, they had declined to 5.3 million acres, 36 percent of the State's timberland area. While the area of poletimber stands decreased between inventories, the area of sawtimber and sapling-seedling stands increased, resulting in a more even distribution of stand-size classes (fig. 6). However, not all forest types have the profile shown in figure 6. The aspen type, for instance, has an age imbalance, which will be discussed later.

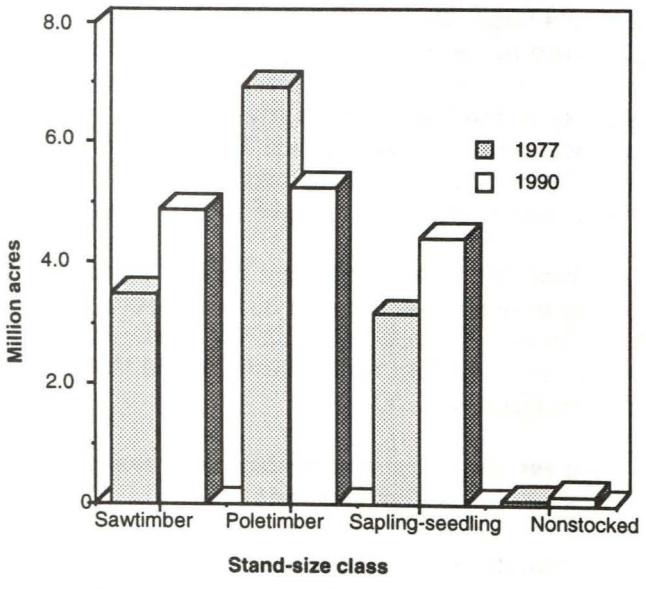

Figure 6.—*Area of timberland by stand-size class, Minnesota, 1977 and 1990.*

The decline of area in poletimber stands was common to all land ownership classes and across all units. On forest industry owned timberland, the decrease of poletimber stands was more pronounced—down 36 percent, compared to 28 percent and 20 percent for nonindustrial privately owned and publicly owned timberland, respectively. In the Central Hardwood and Prairie Units, half of the timberland area in each Unit is in sawtimber-size stands, compared to one-fourth in the Aspen-Birch Unit and one-third in the Northern Pine Unit.

The decrease in area of poletimber stands and the corresponding increases in sawtimber and sapling-seedling stand area reflect the evolving nature of Minnesota's forest. Since 1936, when sawtimber stands totaled only 1.6 million acres, area in the sawtimber-size class has steadily increased to the present 4.9 million acres. A majority of the area in the red pine, white pine, oak-hickory, and maple-basswood types is in sawtimber stands. The white pine and oak-hickory types are especially noteworthy in that 83 percent and 67 percent of their respective areas are in sawtimber-size stands. Sapling-seedling stands predominate in the black spruce and tamarack types with 61 percent and 50 percent of their respective acreage in that size class. Between inventories, the area of poletimber-size stands in the aspen type declined by 38 percent (1.1 million acres), as many of these stands grew into sawtimber size. Aspen sawtimber stands increased by 61 percent (574 thousand acres), and sapling-seedling stands increased by 34 percent (428 thousand acres).

Median Stand Age is 50 Years

The area of the State's timberland by 10-year stand-age classes shows three distinct age groupings: 1 to 40 years old (36 percent of area); 41 to 70 years old (42 percent of area); and 71+ years (22 percent of area) as shown in figure 7. About 2 percent (325 thousand acres) of the timberland area is in stands more than 120 years old. Such stands, if composed of long-lived species such as oak, white pine, and sugar maple, may be considered old-growth forest by some definitions.

Many factors contribute to the age distribution of Minnesota's timberland, including past harvesting activities, fire, and the tree species life cycles.

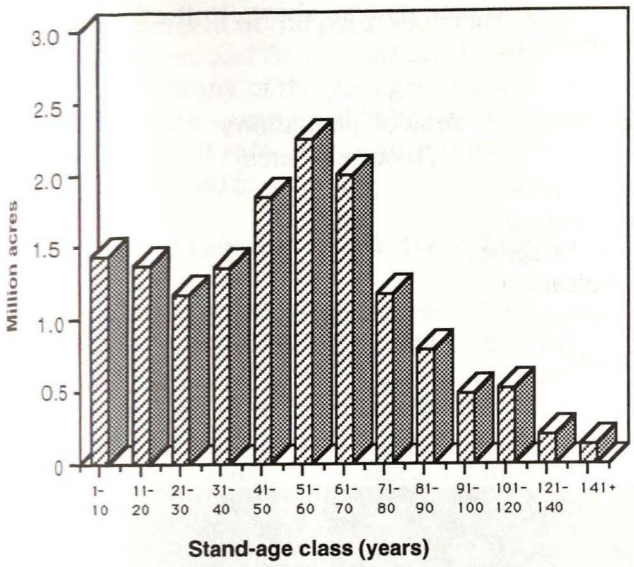

Figure 7.—*Area of timberland by stand-age class, Minnesota, 1990.*

Currently, the median age of stands in Minnesota is about 50 years. The predominance of shorter lived species, such as aspen and balsam fir, contributes significantly to the age dynamics of timberland. For example, 47 percent of the aspen type and 40 percent of the balsam fir type are less than 40 years of age. The northern white-cedar, white pine, and oak-hickory types are more heavily weighted toward the older age classes. Eighty-six percent of the northern white-cedar type is in stands more than 50 years old, and 36 percent is in stands more than 100 years old. This type is usually found in swamps and peat bogs, and many of these stands are difficult or uneconomical to harvest. Eighty-five percent of the white pine acreage is in stands more than 50 years old. Although the white pine type is not as extensive as it once was, about one-fourth of its area is in stands more than 100 years old. These older stands were not harvested because they were inaccessible or because their owners preferred not to harvest. The oak-hickory type consists of more long-lived species—78 percent of oak-hickory stands are more than 51 years old.

The age structure of the aspen type is of special interest because the former "weed tree" is short lived, yet presently in high demand. In 1990, aspen supplied 64 percent of the total growing-stock volume harvested in Minnesota, up from 61 percent in 1988 (Hackett and Dahlman 1993).

The 1990 age structure of the aspen type is presented below:

Age (Years)	Aspen forest type (Thousand acres)	(Percent)
1-20	1,399.6	28
21-40	989.8	19
41-60	1,602.3	32
61-80	908.5	18
81+	154.8	3
Total	5,055.0	100

The distribution of the aspen type by stand-age class suggests three things. First, there is a substantial area of young aspen stands (fig. 8). Second, there is a dip in the area of stands aged 21 to 40 years, which suggests that the waferboard and oriented strand board mills that

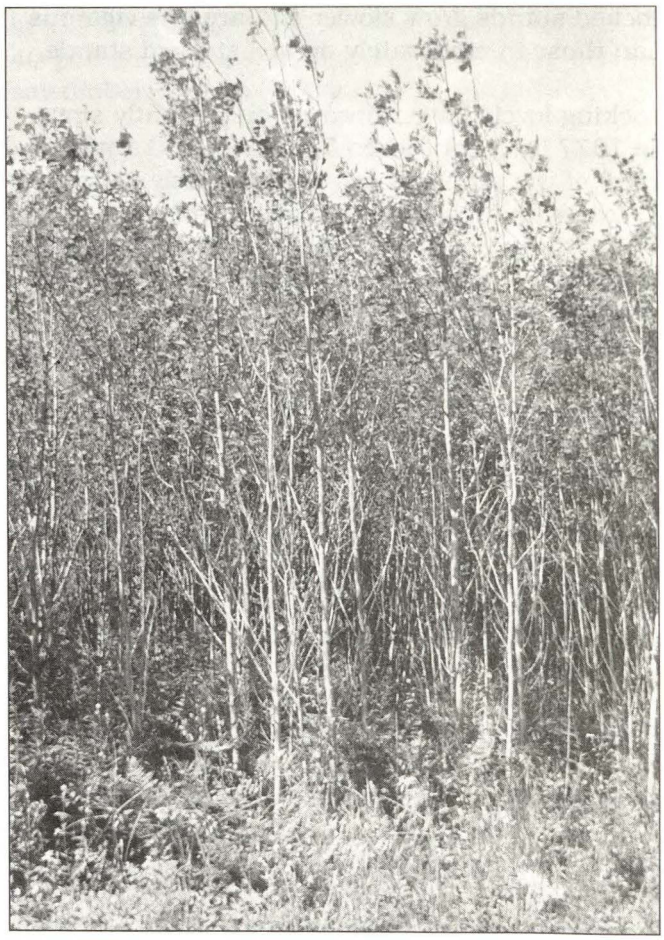

Figure 8.—*This dense aspen sapling stand in Carlton County is representative of young aspen stands in Minnesota.*

have been dependent on a steady and continuous supply of aspen will have to supplement aspen with other species for raw material when these stands are ready for harvest, if industry's production level is to be maintained. Third, the large area of older mature and overmature aspen stands suggests that unless they are harvested, many will deteriorate and convert to more shade-tolerant species.

Overstocking a Problem for Some Stands

Stocking, a relative measure of tree density on the land, provides a means of describing how fully trees are occupying a site. We estimate that 65 percent (9.6 million acres) of the timberland area in Minnesota is moderately or fully stocked with growing-stock trees and 13 percent (1.9 million acres) is overstocked. Between inventories, the area of overstocked stands increased by 1.4 million acres or 245 percent. Trees in overstocked stands grow slower and are less vigorous than those in moderately or well stocked stands.

Stocking levels have improved only slightly since the 1977 inventory when 74 percent (10.1 million acres) of the timberland was moderately or better stocked with growing-stock trees. Stocking differs by Survey Unit. In the Central Hardwood and Prairie Units, about a third of the timberland acreage is poorly stocked or nonstocked, compared with 18 percent in the Aspen-Birch Unit and 20 percent in the Northern Pine Unit. The poorer stocking levels in the two former Units, which are on the prairie fringe, are probably "normal" for the area, given the timing and amount of precipitation in the region. Eighteen percent (1.4 million acres) of the public timberland is poorly stocked or nonstocked with growing-stock trees, compared with 28 percent (1.5 million acres) of timberland owned by individuals.

Two Percent of Timberland in Plantations

An estimated 333.8 thousand acres (2 percent of the State's timberland area) are in forest plantations, 59 percent of which are in the Northern Pine Unit (fig. 9). The Aspen-Birch Unit contains 33 percent of the plantation area, followed by the Central Hardwood Unit with 8 percent. Sixty percent of the plantations grow red pine, and 21 percent grow jack pine as shown in the following tabulation:

Forest type	Area of plantations (Thousand acres)
Red pine	201.7
Jack pine	68.6
White spruce	42.7
Balsam fir	11.3
Others	9.5
Total	333.8

Figure 9.—*Red pine plantations are an important softwood resource.*

Sixty-one percent of the plantations are 20 years old or younger, and 38 percent are 10 years old or younger. Many of the younger plantations—under 10 years—were established at the beginning of CRP and RIM programs and the farm crisis of the 1980's.

Number of Growing-Stock Trees Increases

The number of growing-stock trees—live trees of commercial species excluding cull trees—1.0 inch in diameter at breast height (d.b.h.) and larger increased from 6.3 billion in 1977 to 7.6 billion in 1990, a 22-percent gain. During the same period, growing-stock trees 5.0 inches in diameter and larger increased from 1.9 billion to 2.1 billion, a gain of 10 percent. For every diameter class, the number of trees in 1990 was greater than that in 1977. Species that declined in number of trees were select hickory, select red oak, elm, balsam poplar, paper birch, and butternut. In Minnesota, select hickory is a minor species. Diseases have reduced the number of elm, paper birch, and butternut. The loss of select red oak trees, an important lumber species, is primarily due to the lack of oak regeneration in many stands.

TIMBER VOLUME

Volume Makes Big Gain

The volume of growing stock on timberland in Minnesota increased from 12.4 to 15.1 billion cubic feet between 1977 and 1990, a 22-percent gain (fig. 10). Growing-stock volume includes volume in noncull trees of commercial species 5.0 inches d.b.h. and larger. Softwood volume expanded faster (30 percent) than hardwood volume (19 percent). Sawtimber volume increased even faster than growing-stock volume between inventories, from 24.4 to 34.9 billion board feet[3], a 43-percent gain. Sawtimber volume includes softwood trees 9.0 inches d.b.h. and larger, and hardwood trees 11.0 inches d.b.h. and larger.

This substantial expansion in the amount of wood in standing trees in the State is primarily due to the increase in size of the average tree, as stands continue to mature. The trend to larger

[3] *International 1/4-inch rule.*

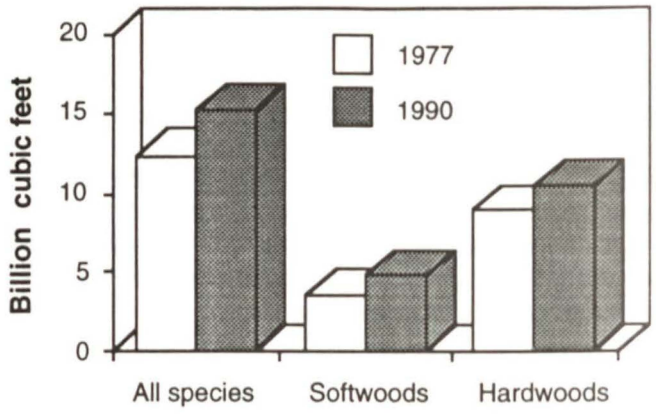

Figure 10.—*Net volume of growing stock on timberland by softwoods and hardwoods, Minnesota, 1977 and 1990.*

tree size is clearly shown for growing-stock trees by the larger volumes and greater number of trees in each 2-inch diameter class in 1990 than in 1977. The increase can also be seen in the 40-percent (1.4 million acres) gain in area of sawtimber-size stands between inventories.

Even though the area of timberland increased by 1.1 million acres between inventories, these added acres did not contribute much to the expanded volumes, because most of them were previously classified as unproductive forest land, cropland, or marshland, on which there were few trees.

St. Louis County Leads in Volume of Timber

The largest timber volumes in 1990 were in the Northern Pine Survey Unit, as shown below:

Survey Unit	Growing stock (Million cubic feet)	Sawtimber (Million board feet)
Northern Pine	6,624.9	15,180.8
Aspen-Birch	5,611.9	11,889.9
Central Hardwood	2,330.9	6,217.1
Prairie	565.4	1,618.7
All Units	15,133.1	34,906.5

St. Louis County contains the largest growing-stock volume by far (2,506 million cubic feet), followed by Itasca County (1,451 million), Koochiching County (1,255 million), Cass County (1,067 million), Beltrami County (921 million), and Lake County (840 million).

Aspen: The Species With the Largest Volume

Hardwoods dominate Minnesota forests, accounting for 69 percent of the total growing-stock volume and for 65 percent of the sawtimber volume in 1990. The aspens (mostly quaking aspen) make up the largest volume of any species group. In 1990, they accounted for 27 percent of the total growing-stock volume and for 39 percent of the hardwood volume.

The aspens are of particular concern in Minnesota, where questions of their management and future supply have been raised. Aspen has not always been a dominant species in the State and, in fact, was a minor component of the forest before the logging boom that extended from the late 1800's to the early 1900's. It is an opportunistic, short-lived, pioneer species that moved in to claim many sites after logging and/or fire, which formerly were occupied by pines and other conifers and hardwoods in the north-central and northeastern portions of the State. Later, after aspen had established a major presence, it was considered a "weed" species and was largely overlooked for its commodity value, except for minor use as pulpwood, until the 1970's when the technology became available to use it in the manufacture of waferboard and oriented strand board.

Area of the aspen forest type is declining as stands decay or "break up" quickly after reaching maturity (about 40 years on average sites to about 60 years on good sites). Many of these stands convert to the shade-tolerant species that have been growing in the understory, such as balsam fir or sugar maple, unless aspen is reestablished by opening up stands to full sunlight by natural disturbance or harvest (fig. 11).

Today, the aspen resource is in such high demand as a mainstay of the forest products industry that there is great concern over whether its supply is sufficient to sustain the present harvest over the long term, and whether that level of harvest might cause environmental degradation in the State. These questions contributed to the initiation of a State-financed Generic Environmental Impact Study (GEIS) on timber harvesting and forest management in Minnesota (Jaakko Pöyry Consulting, Inc. 1994).

Despite the loss of 103 thousand acres of aspen forest type between 1977 and 1990, aspen growing-stock volume rose from 3.5 to 4.1 billion cubic feet, a 19-percent increase (table B). Aspen sawtimber volume increased even faster during the same period, from 5.6 to 9.4 billion board feet, a 68-percent gain.

Figure 11.—*A mature aspen-birch stand with an understory of balsam fir in northeastern Minnesota. This stand will likely convert to balsam fir when the overstory is removed or dies.*

Table B.—*Net volume of growing stock on timberland by selected species groups and percent increase between inventories, Minnesota, 1977 and 1990*

Species group	1977	1990	Percent increase
	Million cubic feet		
Aspens	3,452	4,098	19
Paper birch	1,344	1,459	9
Balsam fir	882	964	9
Select red oaks	667	819	23
Black spruce	592	746	26
Northern white-cedar	499	745	49
Black ash	495	700	41
Basswood	498	692	39
Select white oaks	458	647	41
Balsam poplar	597	595	—
Red pine	403	585	45
Jack pine	495	553	12
Tamarack	271	476	76
Hard maple	287	404	41
Soft maple	177	345	95
All others	1,261	1,305	3
All species	12,378	15,133	22

The oaks, most abundant in the Central Hardwood Unit in the unglaciated hills flanking the Mississippi River in southeastern Minnesota, are another group of species receiving particular attention. These species are slow growing; long lived; in high demand, both domestically and abroad; and extremely slow to regenerate after disturbance. The circumstances for oak are further clouded by the trend towards decline in area of the oak-hickory forest type before the 1990 inventory. It is believed that repeated burning of the forest by Native Americans, as well as wildfire, favored the establishment and maintenance of oaks in presettlement times by killing other less fire-resistant species that might have competed with oaks. As the impact of Native Americans on the forest was overshadowed by the advance of the European settlers and as wildfire was subdued in these stands, other species were permitted to invade and ultimately to dominate some of these oak sites.

However, the declining trend in the oak-hickory forest type was reversed between 1977 and 1990 when area in the type increased by 26 percent. Between inventories, an estimated 110 thousand acres that were formerly cropland reverted to timberland in the oak-hickory type, and an estimated 62 thousand acres that were formerly unproductive forest land were classed in 1990 as being marginally productive timberland in the oak-hickory type. However, the former decline of the oak-hickory type will likely continue in the future unless other land containing oaks is added to the timberland base from other land classes.

The volume of oaks increased between inventories, in spite of a high level of removals. The growing-stock volume of all oaks increased from 1,146 to 1,503 million cubic feet, a 31-percent gain; oak sawtimber volume increased from 3,141 to 4,585 million board feet, a 46-percent gain. Despite the extraordinary demand for northern red oak, its volume also increased. Northern red oak growing-stock volume expanded from 667 to 819 million cubic feet, a 23-percent gain; its sawtimber volume grew from 1,879 to 2,638 million board feet, a 40-percent increase.

Volume Increases For Nearly All Species

Each species group that has substantial volume increased between inventories except elm, which continues to suffer the effects of Dutch elm disease. Elm growing-stock volume in 1990 fell to half its 1977 volume. Even though most species groups gained in volume, some increased much faster than others, resulting in shifts in the percent of the total volume they represent. For example, aspen volume increased between inventories, but it accounted for only 27.1 percent of total growing-stock volume in 1990, down from 27.9 percent in 1977. The same is true of paper birch, the species with the second largest growing-stock volume, which represented 9.6 percent of the 1990 total, somewhat less than the 10.9 percent it represented in 1977.

Conversely, soft maple volume nearly doubled between inventories, accounting for 2.3 percent of the 1990 total, substantially higher than its 1.4 percent in 1977. Soft maple grows fast, competes aggressively with other species, and grows well in the understory of stands because it is shade-tolerant. Therefore, it is an ideal candidate for volume expansion, particularly in stands that contain soft maple in the understory, where disturbance can vault the species into a major component of the residual stand.

The growing-stock volume of softwoods increased faster (30 percent) between inventories than that of hardwoods (19 percent). As a result, softwoods contributed a larger share of the total volume in 1990 (30.7 percent) than in 1977 (28.9 percent). Although the volume of eastern redcedar represents only a minuscule portion of the State's total volume (15 million out of 15,133 million cubic feet in 1990), it tripled between 1977 and 1990, expanding faster than any other species group. Much of this eastern redcedar gain is the result of lands being reclassified as timberland in 1990 that had been classed as unproductive forest land in 1977 and on which there were scattered redcedar trees. Volume on unproductive forest land contributes to volume on timberland if the unproductive forest land is converted to timberland.

Most of the volume of a species is usually found in stands of the forest type with which the species is primarily associated. However, large volumes of some species may be found in other types. An example is white spruce, with only 16 percent of its total growing-stock volume found in the white spruce type, but with 30 percent of its volume in the aspen type, and 18 percent in the balsam fir type. Another example is white pine; 28 percent of its volume is in the white pine type, 21 percent is in the aspen type, and 12 percent is in each of the maple-basswood and red pine types. Thirty-four percent of the balsam fir volume is in the aspen type, compared with only 29 percent in the balsam fir type. Many of these latter stands in the aspen type are converting to the balsam fir type by way of natural plant succession.

Largest Volume Held by Private Individuals

Public agencies administer 51 percent of the growing-stock volume in the State, and private owners account for 49 percent. Private individuals (farmers and other private nonindustrial forest landowners) hold 5.5 billion cubic feet, or 36 percent of the total, more than any other owner class (fig. 12). Private individuals own 36 percent of the State's timberland area as well, and are therefore vital to the success of Minnesota's environmental well-being and to the sustained supply of timber to wood-using industries.

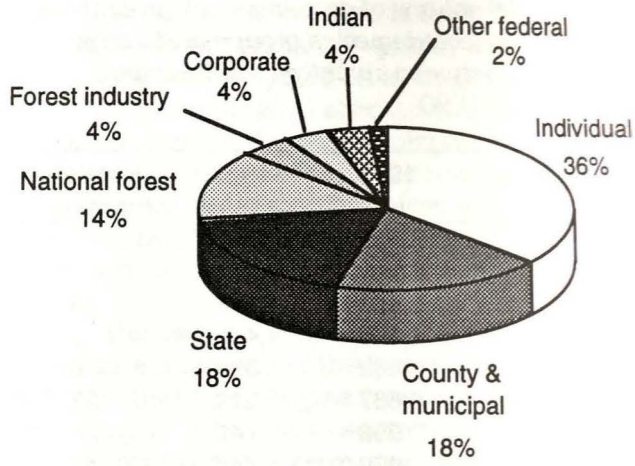

Figure 12.—*Volume of growing stock on timberland by ownership class, Minnesota, 1990.*

Other private forest landowners include forest industry (671 million cubic feet), corporations not primarily engaged in the processing of timber products (589 million), and Indian (541 million).

Among public agencies, county and municipal entities and the State of Minnesota each hold 2.7 billion cubic feet, National Forests account for 2.1 billion, and other federal agencies hold 0.2 billion.

The public owns a greater share of the softwood volume than do private owners, but private owners hold a larger proportion of the hardwood volume. For example, public agencies administer 51 percent of the total growing-stock volume, but 66 percent of the softwood volume. Conversely, private owners hold 49 percent of the growing-stock volume, but 55 percent of the hardwood volume. However, private owners account for only 47 percent of the aspen volume.

Non-Growing-Stock Trees: An Important Resource

The volume contained in rough, rotten, short-log, or salvable dead trees is not included in the above growing-stock (15.1 billion cubic feet) and sawtimber (34.9 billion board feet) volumes. Often overlooked, these trees provide valuable commodity and noncommodity values to the

State. They may provide raw material used in the manufacture of pallets; the technology is also available to join small pieces of wood, such as could be sawn from these trees, to manufacture more valuable, higher quality products. Non-growing-stock trees are also now used for fuelwood, pulpwood, and posts. In addition, they may add to the esthetic enjoyment of the forest, and provide important habitat for wildlife, songbirds, insects, and other plants and animals, thus contributing to biological diversity.

Rough, rotten, short-log, and salvable dead tree volume amounts to a total of 2.2 billion cubic feet, about half of which is in rough trees (table C).

Volumes in Every Diameter Class Increase

Total growing-stock volume was greatest in the 8- and 10-inch diameter classes in 1990, as it was in 1977 (fig. 13). However, the 1990 volume in each diameter class was greater than in the previous inventory. Larger diameter classes made greater proportional increases than smaller classes. For example, the volume in the 16- and 18-inch classes expanded by 52 and 55 percent, respectively, between inventories, but the 6- and 8-inch diameter classes gained only 4 and 7 percent, respectively.

A greater share of the growing-stock volume of softwoods is in small diameter trees than the volume of hardwoods. Forty-nine percent of the volume of softwoods is in the 6- and 8-inch classes, compared with 32 percent of the hardwood volume. Equal amounts of softwood and hardwood volumes (6 percent) are in trees 20

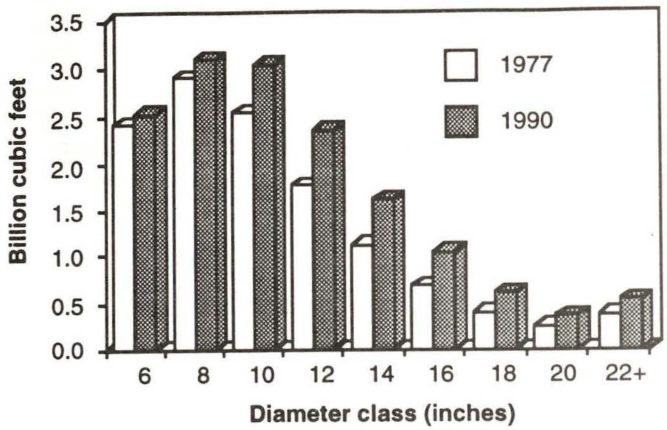

Figure 13.—*Net volume of growing stock on timberland by diameter class, Minnesota, 1977 and 1990.*

inches in diameter and greater. Volume in the largest trees, those at least 30 inches in diameter, is greater for white pine and cottonwood than for any other species. This reflects the presence of scattered, giant white pine survivors of turn-of-the-century logging, as well as the limited markets for and the fast-growing nature of cottonwood. Thirty-three percent of the volume of cottonwood is in trees 30 inches and larger—a greater proportion than for any other species.

Average Volume Per Acre Increases 13 Percent

Average volume per acre of growing stock was 1,028 cubic feet (13.0 cords) in 1990, compared

Table C.—*Net volume of non-growing stock on timberland by class of timber and softwoods and hardwoods, Minnesota, 1990*

(In million cubic feet)

Class of timber	All species	Softwoods	Hardwoods
Rough trees	1,212	148	1,064
Rotten trees	410	65	345
Short-log trees	302	31	271
Salvable dead trees	263	57	206
All classes	2,187	301	1,886

with 909 cubic feet (11.5 cords) in 1977, a 13-percent gain. The white pine forest type had the highest per acre average in both 1977 and 1990 with 1,580 and 2,014 cubic feet, respectively, although it occupies the smallest area of timberland among types. The next largest average per acre volume was in the red pine type (1,406 cubic feet), followed by the paper birch type (1,270 cubic feet), the maple-basswood type (1,252 cubic feet), and the oak-hickory type (1,211 cubic feet). Lowest volumes per acre were in the tamarack (579 cubic feet) and black spruce (575 cubic feet) types.

Largest Volume in Age Classes 41 to 60 Years

Stands aged 41 to 60 years provided 35 percent of the total growing-stock volume in the State, more than any other age class (fig. 14). The short-lived aspen type contributes 45 percent of the volume in the 41- to 60-year class. The volume in this age class declined slightly from that in 1977 as many trees grew out of the 41- to 60-year class and into the 61- to 80-year age class between inventories, which is reflected in the increase in the volume in the latter class. The increases in every class older than 61 years are further evidence of the continuing maturation of Minnesota's forests. Much of the 259 million cubic feet in the aspen type in stands older than 80 years, as well as some of the 1,491 million cubic feet in aspen stands aged 61 to 80 years, is in overmature aspen trees that will soon die.

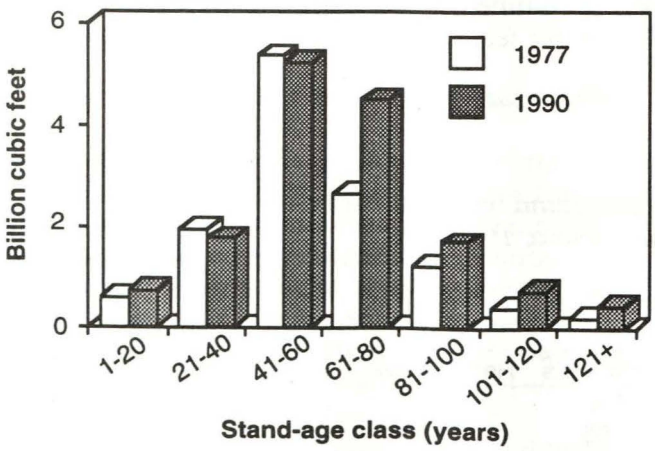

Figure 14. —*Net volume of growing stock on timberland by stand-age class, Minnesota, 1977 and 1990.*

Nearly 8 percent of the growing-stock volume is in stands more than 100 years old, and nearly 3 percent is in stands more than 120 years old—the age commonly considered as one part of the definition for old-growth forests of long-lived species. The long-lived northern white-cedar forest type contains nearly one-third of the volume in stands older than 100 years, by far the largest share. The long-lived oak-hickory and maple-basswood types also contain high proportions of growing-stock volume in stands more than 100 years old—15 and 13 percent, respectively.

Sawtimber Quality is Assessed

Traditional sawtimber quality is not as important now as it was in the past because of technological advancements that create opportunities to convert small diameter roundwood into high quality products. However, the adequacy of sawtimber-size trees for manufacture into high-value sawn or peeled products is still a concern for many in the State. For this reason, field crews assigned a log or tree grade[4] to every sawtimber-size tree on about one-third of the sample plots in the State (see Survey Procedures in the Appendix). The volume by grade from this sample represents the volume in all trees in the State with a similar log or tree grade. The four grades used were based on tree diameter and the presence or absence of knots, decay, crookedness of the bole, or other characteristics in the lowest log of the tree. The relative amounts of these characteristics reflect the quality of the tree for manufacture into high-quality products. Smaller diameter trees tend to be assigned the poorer grades. Because 42 percent of the State's sawtimber volume is in trees less than 14 inches d.b.h., quality is weighted toward the poorer end of the scale. Grade 1 represents the highest quality, and grade 4 represents the lowest quality.

Eighty-four percent of the softwood volume in the State is in trees in which the lowest log is classed as log grade 3 (fig. 15).

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[4] *Log grades were assigned to softwood sawtimber trees in all Survey Units and to hardwood sawtimber trees in the Aspen-Birch and Northern Pine Units. Tree grades were assigned to hardwood sawtimber trees in the Central Hardwood and Prairie Units.*

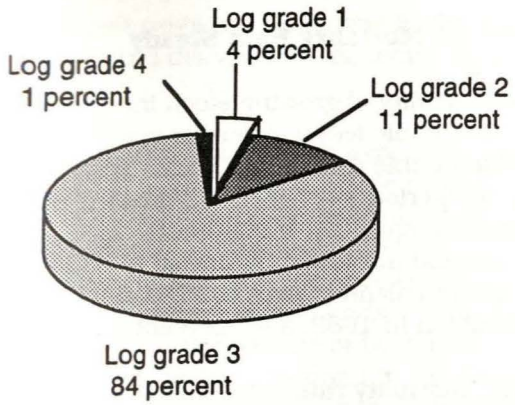


Figure 15.—*Percent of sawtimber volume by log grade for softwoods, Minnesota, 1990.*

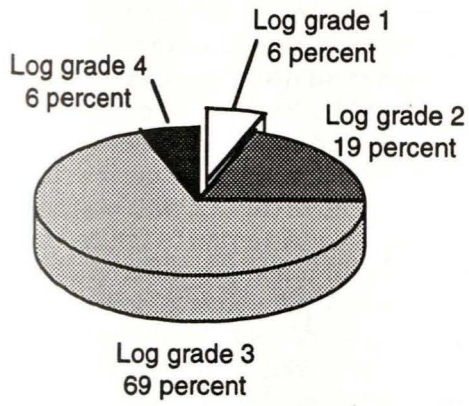
Sixty-nine percent of the hardwood sawtimber volume in the Aspen-Birch and Northern Pine Survey Units is in trees with the lowest log classed as log grade 3. Minnesota Department of Natural Resources field crews performed the field work for these two Survey Units at a time when log grades were being used for both softwoods and hardwoods. Later, when North Central Station field crews began inventorying the Central Hardwoods and Prairie Survey Units, a decision had been made to use tree grades for hardwoods. Therefore, hardwood grade data differ by Survey Unit. Thirty-nine percent of hardwood sawtimber volume in the Central Hardwoods and Prairie Survey Units is in trees with the lowest log classed as tree grade 3, and 32 percent is in trees with the lowest log classed as tree grade 4 (fig. 16).

Among softwoods and hardwoods, the preponderance of sawtimber volume in log/tree grade 3 is in trees in the 10- to 12-inch diameter classes, the smallest diameters for sawtimber-size trees. Trees in these smaller diameter classes may contain limbs or knots in the lowest log, which limit the log/tree grade for that tree.

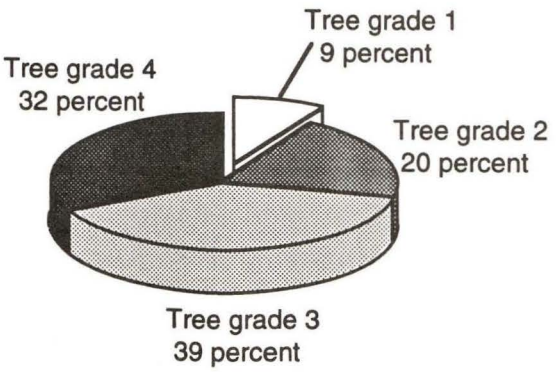
To estimate whether tree quality might improve in the future as trees grow larger, field crews also recorded the limiting factor(s) that prevented the tree from being graded higher. For example, if a tree could not be given a higher grade because its diameter was smaller than the definition allowed for a higher grade, the tree may grow large enough to qualify for the higher grade in the future. Limiting factors include diameter, length of the grading section, presence of surface defects or knots, sweep or crook of the bole, and rot. The presence of surface defects, knots, or limbs was the overriding reason that trees were not graded higher. Some knots will become overgrown with clear wood as the tree ages, perhaps enabling these trees to be graded higher in the future. Where the cost can be justified, intensive management efforts such as individual tree selection, forest pest management, and pruning in high value stands will improve saw log quality.

Volume of Growth Increases

Growth (and mortality) were estimated for two different time periods by two different techniques. Refer to Survey Procedures in the Appendix for a description of these techniques.



Aspen-Birch and Northern Pine Survey Units



Central Hardwood and Prairie Survey Units

Figure 16.—*Percent of hardwood sawtimber volume by log grade (Aspen-Birch and Northern Pine Survey Units) and by tree grade (Central Hardwoods and Prairie Survey Units), Minnesota, 1990.*

The volume of net annual growth of growing stock on timberland in 1989 (current growth—growth during calendar year 1989) was 440 million cubic feet—40 percent greater than the 1976 current growth of 315 million cubic feet. Current growth is useful for comparing growth during two distinct years, but neither of the two years may represent average conditions. Net growth may fluctuate from year to year because of climatic changes or catastrophic mortality. Net growth averaged over the period between two inventories (periodic growth) will even out these fluctuations and therefore may provide a more useful comparison for many purposes. Current growth can only be compared with periodic growth in a general way. During a period of increasing growth, current growth for the latest year will always be greater than periodic growth.

Average annual net growth of growing stock during the period 1977 to 1989 (average growth over the 13-year period) amounted to 370 million cubic feet.

Sawtimber net annual growth in 1989 was 1,603 million board feet, 73 percent greater than the 1976 growth of 929 million board feet. Sawtimber average net annual growth for the period between inventories was 1,312 million board feet.

The current net growth rate for growing stock (growth as a percent of inventory) increased from 2.5 percent in 1976 to 2.9 percent in 1989. Similarly, the sawtimber current growth rate increased from 3.8 percent in 1976 to 4.6 percent in 1989. The 1989 growth rate for hardwood growing stock (3.0 percent) is somewhat higher than the rate for softwoods (2.7 percent). Although the red pine growth rate was 4.3 percent, the overall softwood rate was held down by slow-growing species such as black spruce (1.5 percent), northern white-cedar (2.3 percent), and balsam fir (2.3 percent).

Another way of assessing growth is the volume of growth per acre. In 1976, current growing-stock growth per acre averaged 23.1 cubic feet; by 1989, it had increased to 29.9 cubic feet. Sawtimber growth per acre, averaged across all timberland, rose from 68.2 to 108.8 board feet during the same period. Sawtimber growth per acre in sawtimber stands alone (excluding the growth on sawtimber-size trees in poletimber and sapling-seedling stands and on nonstocked areas) is much higher.

Mortality Rate Steady

Annual mortality of growing stock increased from 169 million cubic feet in calendar year 1976 to 208 million cubic feet in 1989, a 23-percent gain. During the period 1977 to 1989, growing-stock mortality averaged 221 million cubic feet. Sawtimber annual mortality amounted to 303 million board feet in calendar year 1976, and increased to 438 million in 1989, a 45-percent gain.

However, mortality rates changed little between inventories: the growing-stock mortality rate remained at 1.4 percent of inventory for both 1976 and 1989. Similarly, the sawtimber mortality rate edged from 1.2 percent of inventory in 1976 to 1.3 percent in 1989. Thus, although the volume of mortality increased substantially between inventories, it merely kept pace with the rapidly expanding inventory of timber.

Among the various primary causes of growing-stock tree mortality, diseases were responsible for the largest amount (57 percent of the total), weather-related causes accounted for 25 percent of the total, and insects accounted for 8 percent. Animals (3 percent), fire (2 percent), suppression (1 percent), and others (4 percent) complete the list of causes. Although insects were the primary cause of a rather small percentage of the total volume of mortality, they contributed to a much greater share of it by weakening trees and predisposing them to lethal attacks by other agents.

Dutch elm disease was responsible for the greatest share of volume of growing-stock mortality from disease (26 percent), followed by hypoxylon canker (18 percent), which attacks primarily aspen; various stem decay organisms (13 percent); and *Phellinus tremulae* (9 percent), a trunk rot of aspen. Other important diseases include oak wilt, mistletoes, white pine blister rust, root and butt rots, nectria canker, and butternut canker. Windthrow gave rise to the greatest share of tree death among weather-related causes of mortality (69 percent), followed by flooding (16 percent). Hail, lightning, frost, and drought damage accounted for 15 percent. Budworms, including the jack pine budworm and the spruce budworm, accounted for 71 percent of the insect-caused mortality volume. Jack pine budworm defoliates jack pine, and spruce budworm defoliates balsam fir and white spruce primarily. Bole borers and bark beetles also caused substantial volume loss. Programs to

control forest pests are underway in the State, but insects and diseases are endemic in the forest.

Butternut canker presents an especially important threat to a small but valuable resource. The disease is causing extensive mortality of butternut throughout its range in southeastern Minnesota and the Nation, and the species may be added to the threatened and endangered list as a result. Although the volume of butternut, also known as white walnut, is small in the State, its wood is highly valued and its demise would be a major loss. To help protect remaining butternut trees, the State of Minnesota and the USDA Forest Service have declared a harvest restriction on butternut on State and National Forest lands. Also, a program has been established to identify butternut canker-resistant trees, and State tree nurseries are growing butternut seedlings to maintain the gene pool of this species.

Elm, plagued by Dutch elm disease, had the highest growing-stock mortality rate among species—10.0 percent of its inventory, followed by balsam fir (3.3 percent), balsam poplar (2.5 percent), jack pine (1.9 percent), and black spruce (1.9 percent).

Timber Removals Gain

Annual timber removals from growing stock increased from 194 million cubic feet in calendar year 1976 to 261 million cubic feet in 1988, a 35-percent increase. Softwood removals declined from 69 million to 63 million cubic feet, but hardwood removals advanced from 125 million to 198 million cubic feet during the period. The greatest change to a species between inventories was the doubling of aspen removals, from 73 million cubic feet in 1976 to 144 million in 1988, as demand rose for aspen from the oriented strand board industry.

Timber removals are not synonymous with timber harvest. Removals are made up of three components: roundwood products, logging residues, and other removals (see Definitions of Terms in the Appendix). The roundwood products portion includes saw logs, veneer logs, pulpwood, and other products harvested; it represented 86 percent of the total current annual removals for 1988. Logging residues accounted for 6 percent, and other removals accounted for 8 percent of total removals.

Annual sawtimber removals surged from 460 million board feet in calendar year 1976 to 777 million board feet in 1988, a 69-percent gain. Softwood sawtimber removals increased from 170 million to 209 million board feet, and hardwood sawtimber removals gained from 290 million to 568 million board feet during the period. Aspen sawtimber removals alone soared from 173 million to 401 million board feet between inventories.

Timber removals may fluctuate widely from year to year, depending on a host of economic factors. Therefore, another way of assessing removals besides observing figures for single years representing two points in time, is to compare average annual removals between inventories. This method permits a means of leveling the peaks and valleys of demand between years of exceptionally high or low removals. With this approach, average annual timber removals from growing stock amounted to 210 million cubic feet during the period 1977 to 1989. Average softwood removals amounted to 55 million cubic feet, and hardwood removals totaled 155 million cubic feet during the period. Because total current annual removals for 1988 (261 million cubic feet) were greater than total average annual removals for 1977 to 1989 (210 million cubic feet), this suggests that removals were generally higher at the end of the period than at the beginning.

In fact, timber removals did expand during the period. The following tabulation shows an increase in each of the 4 years for which information is available.

Year	Total current removals from growing stock (In thousand cubic feet)
1976	193,600
1984	243,161
1988	261,203
1990	272,104

Growth Exceeds Timber Removals

Average annual net growth of growing stock (370 million cubic feet) exceeded average annual removals (210 million cubic feet) by 77 percent during the period 1977 to 1989 (fig. 13). Average net growth exceeded average removals for both softwood and hardwood totals and for almost all species groups. Growth exceeded removals for the two species groups under the closest scrutiny in the State—aspen and the oaks. As shown in figure 17, aspen growth averaged 124 million cubic feet compared with average removals of 86 million cubic feet during the period, and growth of oaks averaged 33 million cubic feet compared with average removals of 18 million cubic feet. (Even growth for select red oaks, which are in very high demand, exceeded removals by 54 percent.) Removals approached or exceeded growth for only two species—elm and jack pine. Because elm average annual mortality was much greater than elm gross growth between 1977 and 1989, net growth was a negative 11 million cubic feet (gross growth minus mortality equals net growth), compared with the 7 million cubic feet of elm removals. Therefore, elm had an average annual loss of 18 million cubic feet between inventories. Jack pine average annual removals (12 million cubic feet) were only slightly higher than average annual net growth (11 million cubic feet) as demand for jack pine remains high.

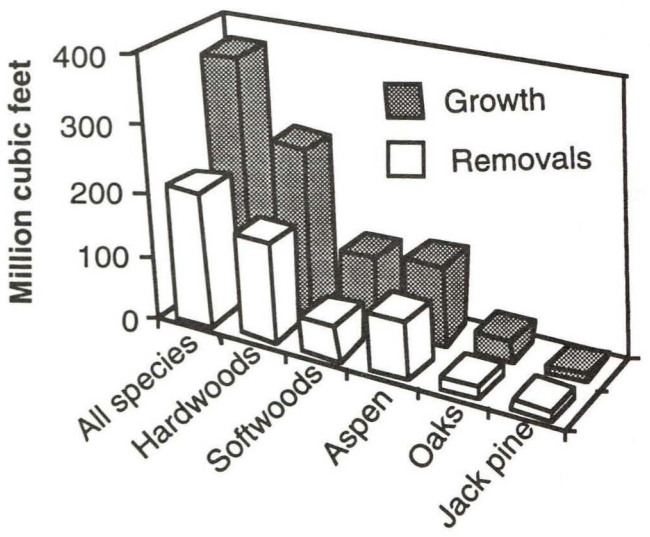


Figure 17.—*Average net annual growth and average annual removals of growing stock, by selected species group, Minnesota, 1977-1989.*

If the difference between current growth (1989) and current removals (1988) of a species is much greater than the difference between average annual growth and removals for 1977 to 1989 for that species, it suggests that removals have fluctuated more widely than the average or that removals have been in a general ascent or descent during the period. Such is the case for aspen, in which current removals (144 million cubic feet) exceed current growth (133 million), and average annual growth (124 million cubic feet) exceeds average annual removals (86 million). This is a result of a general increase in aspen removals during the period, as demand accelerated with the expansion of the particle board industry (fig. 18). An imbalance of removals over growth may be reasonable, at least for short periods of time, for an even-age species like aspen with substantial volume in mature and overmature stands that are contributing little growth, as long as much of the harvest is occurring in those older stands. If these older stands are not being harvested because they are considered less economically attractive than younger stands that contain higher proportions of sound, merchantable wood, the imbalance of aspen removals over growth may be less defensible, especially if it continues for a lengthy period. This situation would also hasten the loss of the aspen forest type as these sites convert to other types.

BIOMASS

Field crews collected information on the aboveground biomass of live trees and shrubs on timberland in the State during the 1990 inventory. With the increasing emphasis on managing forests in an ecosystem-sensitive manner, it is important to learn how much of which plants are present as we understand more fully their role in the forest and how they may be used to benefit society.

Total biomass of all live trees at least 1 inch d.b.h. on timberland amounted to 885 million green tons (weight of live, green trees) in 1990, or an average of 60 green tons per acre. The aspen forest type alone accounted for 308 million green tons, 35 percent of the total, followed by the maple-basswood type with 112 million green tons (13 percent), and the oak-hickory type with 96 million green tons (11 percent).

Figure 18.—*These oriented strand board sheets will be used for wall and roof sheathing in this new house. Oriented strand board, which is made from aspen particles, is cheaper than similar-size plywood sheets.*

Although the white pine type represents the smallest area among forest types in the State and has the smallest total live tree biomass of any type, it contains the largest biomass per acre—85 green tons per acre. The oak-hickory type follows with 83 green tons per acre, ahead of the maple-basswood type (80 tons), and the paper birch type (73 tons). The smallest biomass per acre was in the tamarack type (34 tons) and the black spruce type (41 tons). Differences in biomass among forest types depend on the variation in the specific gravity of individual tree species and the mix of species in a forest type.

The greatest share of live tree biomass is in the boles of growing-stock trees (52 percent), as shown in the following tabulation:

Biomass component	Weight (Million green tons)	Percent
Growing-stock trees >5 in. d.b.h.:		
Stumps	37.0	4
Boles	462.2	52
Tops and limbs	130.0	15
Non-growing-stock trees >5 in. d.b.h.:		
Stumps	6.7	1
Boles	87.5	10
Tops and limbs	24.2	3
Live 1- to 5-inch trees	137.9	15
Total	885.5	100

The biomass of shrubs includes biomass of live tree seedlings less than 1 inch d.b.h., tall shrubs, and low shrubs. The mean shrub biomass on timberland in 1990 was 3,056 pounds per acre green weight, of which 32 percent was in tree seedlings, 60 percent was in tall shrubs, and 8 percent was in low shrubs. The largest mean shrub biomass was in the paper birch and aspen types, with 3,979 and 3,856 pounds per acre green weight, respectively. The smallest mean shrub biomass was in the white pine type (554 pounds per acre).

Among species of tree seedlings, aspen produced the largest mean biomass (267 pounds per acre green weight), followed by balsam fir (122 pounds per acre). Among tall shrubs, alder generated the largest mean (858 pounds per acre), followed by clumped willow (313 pounds per acre); and among low shrubs, raspberry/blackberry was highest (15 pounds per acre), followed by labrador tea (10 pounds per acre).

FOREST PRODUCTS IMPORTANT TO MINNESOTA'S ECONOMY

Forest products have always been an important part of the economy of Minnesota. Before European settlement of the region, the indigenous people relied on the forest to supply most of the resources that supported their cultures and way

of life. The forest products industry is the second oldest industry in the State, preceded only by fur trading. From its beginning on the banks of the Mississippi and St. Croix Rivers, the forest products industry has expanded throughout the State, forming a wide industrial, distribution, and marketing-based complex of economic activities. This discussion of Minnesota's forest products industry will rely on data from a number of published sources. Data sources consulted often did not contain corresponding information because of different reporting periods covered, different parameters used to define the industry, and the fact that some data were unavailable or suppressed to avoid disclosure of information about individual companies. Information is presented to highlight the relative importance of the forest products industry in Minnesota and is not intended to be definitive. Our discussion will focus on the status of the forest product industry around 1990, the period that corresponds to the completion date of the most recent Minnesota forest inventory.

Industrial roundwood products include saw logs, pulpwood, veneer logs, poles, commercial posts, piling, cooperage logs, particleboard bolts, and chips from roundwood used for pulp or board products. Industrial roundwood production (harvest) increased from 223.8 million cubic feet in 1988 to 234.3 million cubic feet in 1990 (Hackett and Dahlman 1993).

The key sectors of the forest products industry in Minnesota are: (1) sawmills and other primary processors; (2) pulpwood purchasers (pulp, paper and reconstituted board processors); and (3) wood product manufacturers-secondary processors. The Minnesota Department of Natural Resources identified firms in each sector (Minnesota Department of Natural Resources and University of Minnesota Extension Service 1990). There were 617 sawmills in Minnesota in 1990. Most of these mills are small operations—two-thirds of them saw under 100 thousand board feet per year. Sixty-two percent of these mills are located in the Aspen-Birch and Northern Pine Survey Units, where 80 percent of the State's timberland is located.

In 1990 in Minnesota, 19 firms used pulpwood in the manufacturing process. Sixteen of these firms were located in the Aspen-Birch (9) and Northern Pine (7) Survey Units, most in or near the communities of Grand Rapids, Duluth, International Falls, Brainerd, Cloquet, Crosby, Cook, and Bemidji. These mills are located in those population centers because of their close proximity to forested land, available labor force, and established transportation systems. In 1990, the Northern Pine Survey Unit was the top pulpwood-producing area in Minnesota (Hackett 1992). St. Louis County, in the Aspen-Birch Survey Unit, was the top pulpwood producing county in Minnesota with 510 thousand cords. Itasca County was second with 380 thousand cords. Counties producing more than 100 thousand cords were Koochiching, Beltrami, Cass, and Lake. Wood pulp is used to produce paper—especially high quality book and magazine papers, hardboard, roofing felt, sheathing, ceiling panels, and decorative tiles. The pulp-using firms can be viewed as export firms because many of their products are generally exported from the region. A good transportation system and proximity to the large Midwest markets give Minnesota pulp-using firms a competitive advantage, particularly with respect to the Southern and Western States.

A growing and important sector of the forest products industry in Minnesota is particleboard manufacturing, which includes oriented strand board and waferboard. Between 1981 and 1985, four new particleboard mills began operations in the State. In 1990, particleboard output from mills in the State was an estimated 582 million square feet at three-fourth of an inch thickness, placing Minnesota second to Michigan, which produced 613 million square feet (Hackett 1992).

In 1990, there were 789 wood product manufacturers in Minnesota (Minnesota Department of Natural Resources and University of Minnesota Extension Service 1990). These firms are secondary processors, using wood-based products, but not roundwood, to manufacture products for the consumer market. Most of these firms employed fewer than 15 workers, and nearly half were concentrated in the seven-county Twin Cities Metropolitan Area. Products manufactured by secondary producers include furniture, flooring, cabinets, windows, doors, millwork, pallets, boxes, and building materials.

The processing of wood into products creates economic activities that ripple throughout the

entire economy. According to information released by the Minnesota Department of Trade and Economic Development (Timber Producer Bulletin 1994), the forest products sector in the State grew twice as fast as that in the Nation as a whole, more than doubling to annual shipments of $6 billion between 1982 and 1991. Employment levels in the forest products sector in 1991 stood at 55,451 workers, a gain of more than 10,000 from 1982. Annual average employment growth from 1982 to 1991 was more than twice the national average—2.3 percent versus 1.0 percent. The annual average growth in employment is significant considering that 17 other States surpass Minnesota in timberland area. Annual average growth of payroll in the forest products industry was higher in Minnesota than in the rest of the country. Average annual growth (1982 to 1991) in Minnesota was 7.8 percent compared to 4.7 percent in the United States. Minnesota's $1.1 billion forest products payroll accounted for 9.2 percent of the State's manufacturing payroll.

According to the U.S. Department of Commerce, Bureau of Census (1990), value added by the forest products industry—manufacturing establishments in the lumber and wood products, and paper and allied products industries[5] (Standard Industrial Classification Codes 24 and 26, respectively)—was $2.6 billion in 1990, compared with $903.5 million in 1977. Value added by manufacture identifies the amount of money added to the economy by harvesting and processing of the raw material. The increase in value added is partly attributable to equipment purchases and plant expansions or additions, especially in the pulp and paper making establishments. In 1990, a new plant that makes composite lumber was completed at Deerwood. In International Falls, a major pulpmill expansion was completed in 1991. New capital expenditures in the pulp and papermaking industry increased from $37.5 million in 1977 to $235 million in 1990. In the lumber and wood products industry, technological advances in wood utilization contributed to a rise in value added.

[5] *Lumber and wood products manufacturing establishments include sawmills, planing mills, millwork, wood building manufacturers, and mobile home manufacturers, and miscellaneous wood products producers. Paper and allied products include paper mills, paperboard containers and boxes, and miscellaneous converted paper products.*

Fuelwood production and consumption from roundwood is an important use of wood in Minnesota. Industrial use of fuelwood increased substantially during the 1970's and 1980's. In the early 1970's, markets were poor for fine residue (sawdust and shavings) and bark. For example, 75 percent of the fine residue and 79 percent of the bark generated by primary mills was not used in 1973 (Blyth *et al.* 1979). By 1990, use of fine residues for industrial fuelwood had increased slightly to about 26 percent of all fine residues (95 thousand tons), but 90 percent (947 thousand tons) of the bark from primary wood using mills in Minnesota was used for industrial fuelwood (Hackett and Dahlman 1993). Several wood burning heating systems have been developed for public facilities such as schools. However, it is difficult to estimate the economic contribution of fuelwood production to the State's economy because most fuelwood producers are household producers rather than commercial producers. Total output of residential fuelwood from roundwood during 1988 in Minnesota was 1.1 million cords (Hackett *et al.* 1991). In 1988, households in Minnesota cut 84 percent of the fuelwood produced. According to Hackett *et al.* (1991), the Central Hardwood Survey Unit supplied 44 percent of the 1.1 million cords of fuelwood cut from roundwood in 1988. The Central Hardwood Survey Unit, although containing only 15 percent of the State's timberland area, is the primary fuelwood producing region because most of the State's households are located there—half of the State's people live in the seven-county Twin Cities Metro region. The Northern Pine Survey Unit supplied 23 percent and the Aspen-Birch Unit supplied 16 percent. St. Louis County was the only county to produce more than 100,000 cords of fuelwood. Although it is difficult to estimate the economic value of fuelwood produced and consumed, the volume of residential fuelwood produced in Minnesota contained sufficient heat value to replace approximately 100 million gallons of No. 2 fuel oil (Hackett *et al.* 1991).

MINNESOTA'S FORESTS PROVIDE MANY BENEFITS TO THE PUBLIC

The influence of the forest on people is evident in almost every town and city in Minnesota. Forest land in the State is viewed in the context of the "Northwoods." The Northwoods provided the backdrop for such folklore as the Paul Bunyan/

Babe the Blue Ox tales, and was the source of wood products for European settlement of the Midwest and Great Plains. But, Minnesota's forests are more than the Northwoods and more than a source of timber or wood products. Minnesota's forests produce a wide variety of benefits and values that millions enjoy.

Nontimber products from Minnesota's forests, although sometimes difficult to quantify, may have more value than timber products. Nontimber forest resource values include water quality, biodiversity, soil protection, wildlife habitat, visual diversity and aesthetics, special products, and outdoor recreation. Each of these nontimber resources will be discussed separately, but they are all related. Each resource/use of the forest is an integral part of the whole forest; each adds its diversity and values to those of other resources, enriching the forest.

Water Quality

Minnesota's water resources include 25,000 miles of fishable streams, 15,000 lakes, and 7 million acres of wetlands that provide habitat for about 150 species off fish (Jaakko Pöyry Consulting, Inc. 1992e). In addition, many terrestrial wildlife species depend on the water resource. That resource serves as one of the primary attractions for recreationists interested in water-based activities such as boating, canoeing, and fishing. The quality of these resources and activities is directly related to the quality of the water resource.

In Minnesota, forest and water resources interact and have direct impacts on each other. All of the almost 17 million acres of forest land in the State influence water quality and quantity on both the surface and underground. As an example, the percent of forest cover within a watershed was found to be one of the best predictors of water quality in streams in Minnesota (Jaakko Pöyry Consulting, Inc. 1992e). Minnesota's 2.7 million acres of forested wetlands, with swamp conifer species such as black spruce, northern white-cedar, and tamarack, are prime examples of forest and water interactions. As the water table rises or falls, or the water quality improves or degrades, the impact of this change is directly reflected by the health and vigor of the swamp conifer forest.

Relations between forest lands and water are complex, and several variables can positively or negatively impact either resource. Forest management can have beneficial as well as detrimental impacts on water quality, depending on the timing, techniques, and size of the operations.

Riparian zones are the banks and adjacent areas of lakes, rivers, and streams where additional soil moisture provides a moister habitat than that of adjoining uplands. In Minnesota, some of the most productive forest sites are found in the riparian zones. Increased production is due to the permanent water influences on the soils and vegetation. Forested riparian zones play a critical role in maintaining the State's water quality. Trees in riparian zones protect the streambank from erosion as their roots help to hold the soil in the bank rather than to slough into the stream. These zones act as buffer/filter strips, filtering out sediments and nutrients from the water as it flows through the vegetated area. Riparian vegetation slows down the water, allowing sediment and other pollutants to settle out onto the land rather than to be carried into the stream or lake. Vegetation may grow through the deposited sediment, stabilizing it with roots and covering it with plants that use the nutrients that would otherwise harm downstream water quality.

Sediment is the major cause of non-point water pollution in the United States (Welsch 1991). In Minnesota, the risk of high rates of sediment production from most forest land is low due to the relatively flat landscape, the holding capacity of the organic matter and root systems, and the growing use of Best Management Practices (BMP's) in forestry operations. BMP's are practical forest management procedures designed to reduce pollution from nonpoint sources, and involve streamside management and water control (USDA Forest Service 1989). BMP's are ways to build roads, harvest timber, and do other forest operations, while keeping streams and lakes clean. Some areas, such as in the Aspen-Birch Unit and in the hills of southeastern Minnesota, have steep terrain and erodible soils where there is great potential for sedimentation to occur, but these sites are local in nature and not of widespread concern. Potential sedimentation rate is a primary factor in determining proper BMP's for forest management activities.

As increasing numbers of landowners comply with BMP recommendations in their forestry operations, rates of sedimentation from forest land should steadily decline.

Forested riparian zones slow flood waters and reduce the likelihood of downstream flooding. They serve as water infiltration zones to smooth out high and low water flows. Water infiltrates into the forest soil during high flows, such as during the floods of 1993 in the southern half of Minnesota, and it is released during low flows.

Water temperature, habitat structure, and food availability are important factors affecting the survival of fish, and these factors are directly affected by streamside forests. Trees provide shade along Minnesota's streams, rivers, and lake edges. Shade maintains lower water temperatures (a direct reflection of water quality and occurrence of algal growth) and provides improved habitat for a diverse invertebrate community. Water temperature impacts the available oxygen in the water—as temperatures rise, oxygen levels drop. Forested riparian zones serve as sources of organic matter and coarse woody debris. Organic matter is necessary for the existence of aquatic insects used as food by fish. Coarse woody debris in the rivers, streams, and lakes provides food and habitat for various water-related organisms. As the percent of woody vegetation in the riparian zone increases, so does the percent of organic matter available to improve fisheries habitat.

Minnesota's forest land area continued to expand between 1977 and 1990. This expansion occurred as nonforest lands such as cropland, pasture, and wooded pasture were converted to trees. If the expansion of forest land area continues, the water quality benefits associated with forests will increase. The quality of Minnesota's water in the future will mirror the area, health, and vigor of its forest.

Soil Erosion Protection and Enhancement

Soils are the fundamental resource on which rests the ability of land to provide a wide array of benefits. Humankind and wildlife rely on soils for the production of life-sustaining food and shelter. The long-term productivity of our soil resource is of primary concern for everyone.

Erosion reduces soil fertility, has off-site impacts, and reduces the economic value of land. For forestry and agriculture, maintenance of site productivity is key to sustainable management.

Forests protect the soil both directly and indirectly from wind and water erosion. Wind erosion rarely occurs in wooded areas due to the forest canopy, strong soil support provided by tree roots, and mulch on the forest floor. In addition to the protection provided by forests, trees on other areas such as windbreaks, wooded strips, wooded pastures, and croplands protect the soil from wind erosion. Windbreaks lower soil erosion by slowing down the wind as it passes over a field. In 1990, Minnesota had more than 105 thousand acres of windbreaks, 65 percent of which were located in the Prairie Unit where soil erosion of croplands is a concern. The benefits of windbreaks extend leeward for a distance of at least 10 times the height of the trees (Wardle and Schmidt 1984). Thus, Minnesota's windbreaks have a positive impact on hundreds of thousands of acres of cropland. In addition, in 1990 there were about 101 thousand acres of wooded strips in Minnesota, 32 percent of which were in the Prairie Unit. These wooded strips are often found adjacent to croplands and help to protect soil from wind erosion.

Wooded strips are also found along drainages in riparian zones. These forested areas are some of the most valuable in the State in terms of protection from soil loss. Soils along drainages are easily eroded when the land changes from forested to other uses such as croplands or pasture. Soil erosion on these areas not only degrades the specific site, but also can cause other off-site damages downstream.

Forest land generally has a low rate of sheet and rill erosion. On undisturbed well-managed forest land in the Eastern United States, the soil has an average erosion rate of 0.05 to 0.1 tons per acre per year (Patric 1976). However, due to the high level of organic matter contributed by leaf drop and fallen limbs, branches, and boles, most healthy forest ecosystems create soil rather than lose soil. This new soil increases the future potential productivity of the site.

Off-site impacts from soil erosion include loss of water oriented-recreational opportunities because of turbid waters in streams, rivers, and

lakes; costs of dredging to maintain channels in navigable waters such as the Mississippi and St. Croix Rivers; and increased costs from flooding where sedimentation has reduced the channel capacity of riverbeds. Forest lands, especially those in the riparian zone, can lessen the off-site impacts from soil erosion.

Forest soils can suffer nutrient loss, soil compaction, and soil erosion due to timber harvesting (Jaakko Pöyry Consulting, Inc. 1992c). These problems can be mitigated through proper timing and techniques such as retaining as much organic material as possible on the site, harvesting during winter and dry periods, and being aware of the soil type and its susceptibility to compaction and erosion. If recommened practices are not followed, timber harvesting and other forest management activities can lead to erosion rates in some skid trails and haul roads that are greater than the soil loss tolerance value established by the Soil Conservation Service's Universal Soil Loss Equation (Jaakko Pöyry Consulting, Inc. 1992c).

Wildlife Habitat

Wildlife plays a major role in the quality of the environment. The diversity of Minnesota's forest resource provides a complex habitat for many wildlife species. People realize that wildlife contributes to the quality of life through hunting and fishing, watching or photography, or through just knowing that wildlife exists and is part of our world. Many people are willing to spend time and money to satisfy their desire for a wildlife-related experience.

Minnesota is blessed with many wildlife species. There are approximately 80 species of mammals in the State, 20 of which are associated with forest habitats. The State claims 304 bird species as residents during all or part of the year, at least 148 of which require forested habitat for part of their life cycle. Statewide, there are 47 species of amphibians and reptiles (Jaakko Pöyry Consulting, Inc. 1992b).

Forest-related wildlife species are a vital ingredient of the forest ecosystem. The population size of many species is directly related to the amount and kind of woody vegetation available to them. Deer, raccoon, squirrels, wild turkey, ruffed grouse, and other woodland-dependent species exist in abundant numbers within the State due to the forest resource. If the acreage of woody vegetation were to increase, the wildlife resource could increase correspondingly. In addition to the above species, many others depend somewhat on forests/trees for their survival. Pheasants are normally associated with farmland in western or southern Minnesota, but abundant forest winter cover, whether found as windbreaks, wooded strips, or woodlands, has a dramatic positive influence on their population.

The red-shouldered hawk and the Louisiana waterthrush are currently the primary forest-related wildlife species of special concern in Minnesota because of the potential negative impacts on their populations from timber harvesting operations (Jaakko Pöyry Consulting, Inc. 1992b). In addition, the gray wolf, pine marten, osprey, bald eagle, loggerhead shrike, peregrine falcon, wood turtle, rat snake, and eastern hognose snake are some forest-related species that are included on either Federal or State lists of endangered or threatened species, or are species of special concern.

Several forest-dependent wildlife species are of economic importance due to their value for hunting and trapping. Snowshoe hare, gray and fox squirrels, beaver, white-tailed deer, moose, black bear, ruffed grouse, and wood duck are species that can legally be taken, and they depend on the forest for their survival. These species contribute indirectly but significantly to the State's economy through hunting license receipts, sale of equipment, and other revenues. White-tailed deer, Minnesota's most important big game animal in terms of number of hunters and amount of economic activity, illustrate these economic contributions, with harvests averaging almost 140,000 per year (Preece 1989). In 1991, a record 210,000 white-tails were harvested, helping to generate about $400 million of expenditures from consumptive and non-consumptive recreation (Jaakko Pöyry Consulting, Inc. 1992b).

Timber harvesting provides multiple benefits for Minnesota's white-tailed deer. Logging provides more feeding territory and sets back the successional stages of the forests (Preece 1989). When hardwood forests reach poletimber-size, the trees are not as available for food as sapling-size trees, and they shade out desirable food plants and

shrubs. Minnesota has almost 2.8 million acres of hardwoods in the preferable sapling and seedling stand-size class, serving as the "dinner table" for white-tails. When abundant, deer browsing on tree seedlings can have a severe impact on the regeneration of some tree species, particularly white pine.

Mature northern white-cedar is believed to be the best winter cover for deer in northern Minnesota (Doepker and Ozoga 1990). In 1990, more than 415 thousand acres of the northern white-cedar forest type in northern Minnesota were more than 80 years old. These acres provide prime wintering habitat for deer. In addition, white spruce, pines, and balsam fir provide relatively good winter cover. Conifer cover is critical for providing thermal protection, for reducing snow depth, and for reducing surface crusting in the more northern areas of the State where cold and snow can severely limit white-tailed deer survival.

The gray wolf is a forest-dependent species of great interest in Minnesota. The State has the largest remaining population of gray wolves in the lower 48 States. Early stages of forest succession or disturbed forests tend to be the most productive for gray wolves. Wolves depend on other forest wildlife species such as deer, moose, beaver, and hares for prey. As these prey species populations rise and fall in response to natural cycles and to the character and size of the forest resource, the gray wolf population will respond accordingly.

Many birds depend on Minnesota's forest resource for nesting cavities, food, and other needs. Cavity nesting species such as woodpeckers and owls need mature forests, while species such as brown thrashers require open, younger forests. Bird communities in mature forests are distinctive from those in early successional stages. Generally, a complete turnover of bird species occurs after harvesting. As the forest ages, bird species diversity increases because species associated with older forests colonize the area while species associated with younger forests maintain some presence. The Central Hardwood Unit, especially the area along the Mississippi River, has the greatest diversity of forest birds. Many species of birds, including bald eagles, nest in the flood-plain forest or in the hardwoods along the bluffs and unglaciated hills of the region.

The ruffed grouse is the State's most abundant game bird, with annual harvests of more than a million birds in peak years. Minnesota ranks among the top four States in terms of number of grouse hunters, with up to 151,000 hunters annually (Preece 1988). Ruffed grouse live throughout the State where aspen is found, and they feed on aspen buds and flower catkins. Although many wildlife species in Minnesota receive public attention due to their need for undisturbed mature forests, grouse thrive with aspen timber harvests. An optimum prescription for ruffed grouse would include harvests on one-fourth of their aspen habitat every decade (Gullion 1984). Sapling-seedling aspen stands provide the best cover for approximately 10 to 15 years until the stand naturally thins with age (fig. 19).

Figure 19.—*This aspen sapling stand near Cloquet, Minnesota, is an example of the best ruffed grouse habitat in North America, according to the late, internationally respected wildlife biologist from the University of Minnesota, Dr. Gordon Gullion.*

Beaver is a forest-related species that has experienced tremendous changes in its population. In 1900, beaver was all but wiped out in Minnesota and the rest of the United States because of overharvesting. But aspen, the beaver's favorite food, began to replace the old-growth pine forests cut at the turn of the century; as a result, the beaver returned in Minnesota to the point where by 1939 trapping was again permitted (Hutchinson 1989). Currently, a viable population of beavers is found throughout the State. As the forestry profession continues to become more sensitive to all forest resources, wildlife will play an increasingly larger role in determining appropriate forestry-related actions.

Visual Diversity and Aesthetics

Minnesota's forest resources are a primary reason the State is famous for its scenery. Forests occupy about 33 percent of the total land area, while croplands account for 51 percent. The remaining 16 percent of the land area in Minnesota is comprised of pasture, urban areas, small towns, roads, and other land. The diverse land uses combine into an attractive mosaic.

Contributing to the visual mosaic in Minnesota is the diversity of the forest—14 different forest types, including 8 conifer types and 6 deciduous types. This diversity is higher than in most other States. Minnesota has prairie-related forests, such as elm-ash-cottonwood; northern boreal forests, such as aspen and paper birch; swamp-related forests, such as black spruce; and central hardwood forests, such as oak-hickory.

Timber harvests and other forest management practices can impact the visual quality of Minnesota's forests. The intensity of harvest, amount of slash left, and time since harvest are factors that influence scenic quality. Generally, smaller operations with reduced slash have less impacts on scenery, especially as time progresses (Schroeder *et al.* 1993).

Special Products

Minnesota's forest land produces a variety of products that are not related to the harvesting of wood fiber, including cones, decorative greenery, dried florals and ornamentals, herbs and medicinals, and maple syrup (Mater 1993). Tamarack and white spruce cones are used in the potpourri industry, and scotch pine cones dominate the cone wreath industry. The Minnesota evergreen wreath industry sells about $10 million of products annually (Mater 1993). White birch tree tops from Minnesota are used to provide interior decor with a "back-to-nature" motif. The bark from black cherry trees is used extensively in cough medicines (Mater 1993).

Maple syrup production in Minnesota is undertaken by both commercial producers and hobbyists. In 1992, there were 78 commercial operators and more than 3,000 hobbyists involved in maple syrup production (Minnesota Agricultural Statistics Service 1992). In 1992, over 12,000 gallons of syrup were produced by commercial operations in the State with a crop value of about $340,000 (Minnesota Agricultural Statistics Service 1992). An additional 21,000 gallons of syrup were estimated to have been produced by hobbyists for their own consumption. When commercial and hobby production is combined, the retail value of Minnesota's maple syrup approaches $1 million.

Outdoor Recreation

Outdoor recreation and Minnesota forests are almost synonymous for many people. Although the State has a diversified economy, its natural resource-based outdoor recreation provides substantial economic inputs. The quality of the outdoor recreation experience is a reflection of the quality of the resource. Outdoor recreation activities that rely directly on the forest resource include camping, picnicking, cross-country skiing, nature study, and hunting.

In Minnesota, more than half of all natural resource-based outdoor recreation occurs in the more heavily forested northern half of the State (Jaakko Pöyry Consulting, Inc. 1992d). Most of the land available for outdoor recreation in this area is owned by the State and Federal Governments. The Boundary Waters Canoe Area Wilderness, the Voyageurs National Park, and many of the popular State parks are located in northern Minnesota.

Outdoor recreation is a prime example of the interdependence of the forest resource and its various values and products. Forest management activities such as harvesting or thinning can directly impact, positively or negatively,

other forest-related activities such as camping, hunting, or fishing. In addition, forest-related outdoor recreation activities impact the forest resource.

MINNESOTA'S TIMBER RESOURCE: A LOOK INTO THE FUTURE

Expansion of Timber Supply Projected to Continue

We made two sets of 30-year projections of Minnesota's timber situation to gain perspective on the future timber resource and to assess the State's role in helping to meet the Nation's timber needs. One of the projections assumes a continuation of recent levels of timber removals (low removals option), and the other assumes an accelerated level of timber removals (high removals option). Separate sets of projections were made for softwoods and for hardwoods.

Assumptions used in making the projections are: (1) the total area of timberland will decline by an average of 0.172 percent per year between 1990 and 2020, from 14.7 to 14.0 million acres; (2) the availability of timberland for harvest will remain the same as in the recent past; (3) growth rates for softwoods and hardwoods will remain constant at the 1989 level during the projection period for both the low and high removals option projections; (4) removals rates for softwoods (1.36 percent) and hardwoods (1.88 percent) will remain constant at their 1988 levels for the low removals option projections, and removals rates for softwoods (1.36 percent increasing to 2.29 percent) and hardwoods (1.88 percent increasing to 2.81 percent) will increase substantially for the high removals option projections; (5) there will be no changes in the economic, social, or political structure.

The assumption of a slightly declining area of timberland differs from the assumption used in the Generic Environmental Impact Statement (GEIS) Study on Timber Harvesting and Forest Management in Minnesota (1994) prepared by Jaakko Pöyry Consulting, Inc., which is discussed later under The Outlook. The GEIS study assumed that area of timberland would increase by 106 thousand acres between 1990 and 2040, due largely to reversion from marginal agricultural lands in the southern part of the State, offsetting expected losses of timberland in the north due to development for other uses.

Our rationale for assuming a declining timberland area is as follows: Timberland area declined in each of the first four statewide inventories as this land was developed for roads, power lines, urban areas, and other uses. A major reason for the increase in area between 1977 and 1990 was the fact that 493 thousand acres of land growing swamp conifers, classed as unproductive forest land (called other forest land in this report) in 1977, were reclassified as marginally productive timberland in 1990 and were added to the timberland base. It is unlikely that similar reclassification of other land use classes to timberland will occur in the future. Although marginal agricultural land is reverting to timberland in southern Minnesota, it is questionable if reversion alone may not be sufficient to offset future continued losses of timberland throughout the rest of the State. And reversion can be slowed or reversed when changing prices for agricultural commodities reach a level considered profitable by farmers, and those farmers begin to use the cropland again that they had allowed to revert to timberland.

Low Removals Option Projection

In this projection for growing stock, timber removals increase 34 percent, from 261 million cubic feet in 1988 to 351 million in 2020 (fig. 20). Growth remains higher than removals during the entire period, increasing from 440 million cubic feet in 1989 to 596 million in 2020, a 35-percent gain. The difference between growth and removals widens each year, resulting in an expanding inventory. Growing-stock inventory increases from 15.1 billion cubic feet in 1990 to 20.5 billion in 2020, a 36-percent gain.

Softwood removals increase from 63 million cubic feet in 1988 to 90 million in 2020. The removals rate remains constant during the projection period because inventory increases. Softwood growth increases from 125 million cubic feet in 1989 to 178 million in 2020 and exceeds removals in 2020 by 88 million cubic feet. This growth excess results in an expansion of the softwood inventory from 4.6 billion cubic feet in 1990 to 6.6 billion in 2020, a 42-percent gain.

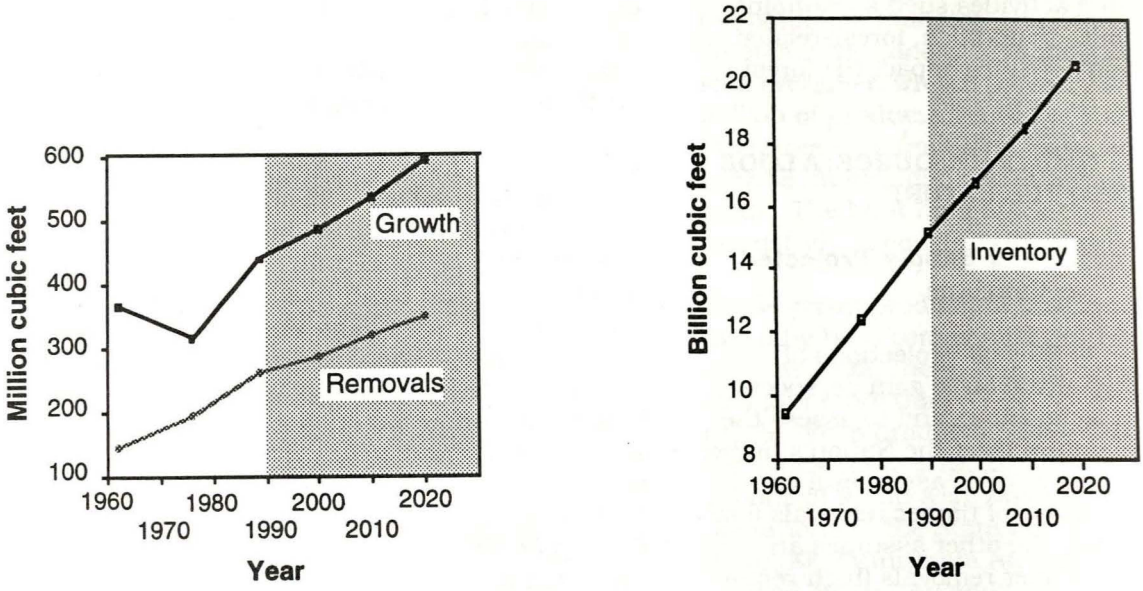


Figure 20.—*Removals, net annual growth, and inventory of growing stock on timberland, Minnesota, 1962, 1977, and 1990; and low removals option projections to 2020.*

Removals of hardwoods increase from 198 million cubic feet in 1988 to 262 million in 2020, a 32-percent gain. Hardwood growth increases from 314 million cubic feet in 1989 to 418 million in 2020 and exceeds removals in 2020 by 156 million cubic feet. Hardwood inventory builds from 10.5 billion cubic feet in 1990 to 13.9 billion in 2020, a 33-percent increase.

High Removals Option Projection

The high removals option shows growing-stock removals increasing by 81 percent, from 261 million cubic feet in 1988 to 472 million in 2020 (fig. 21). Growth remains greater than removals throughout the projection period, but, the two converge. Growth exceeds removals by only 47 million cubic feet in 2020, compared to 179 million in 1989, as the growth rate remains constant and the removals rate increases. Growth rises from 440 million cubic feet in 1989 to 519 million in 2020, an 18-percent gain. Inventory increases at a slower rate than for the low removals option and begins to level off from the previous rapid increases from 1962 to 1990. The inventory of growing stock increases from 15.1 billion cubic feet in 1990 to 17.9 billion in 2020, a 19-percent gain.

Softwood removals more than double, from 63 million cubic feet in 1988 to 131 million in 2020, a 108-percent increase. Softwood growth increases from 125 million cubic feet in 1989 to 155 million in 2020, a 24-percent gain. Softwood growth exceeds removals by only 24 million cubic feet in 2020, compared to 61 million cubic feet in 1990, resulting in a slowing rate of increase in inventory during each decade of the projection period. Softwood inventory increases moderately from 4.6 billion cubic feet in 1990 to 5.7 billion in 2020, a 24-percent gain.

In this option, hardwood removals rise 72 percent, from 198 million cubic feet in 1988 to 341 million in 2020. Hardwood growth gains only 16 percent, from 314 million cubic feet in 1989 to 364 million in 2020. Hardwood growth exceeded removals by 114 million cubic feet in 1990, but the difference is projected to narrow to 23 million by 2020. Hardwood growing-stock inventory advances modestly from 10.5 billion cubic feet in 1990 to 12.1 billion in 2020.

THE OUTLOOK

These projections represent the forest situation in Minnesota over the next 30 years only if the

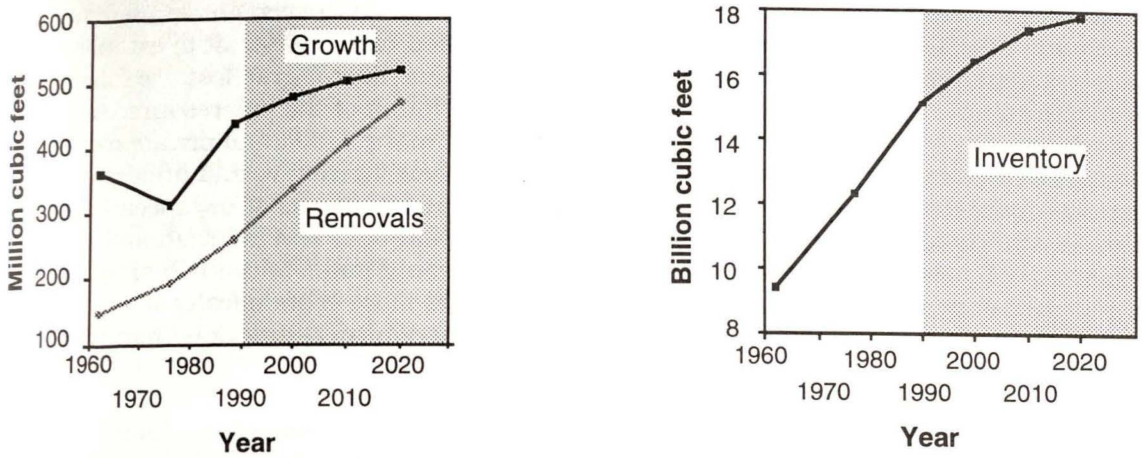


Figure 21.—*Removals, net annual growth, and inventory of growing stock on timberland, Minnesota, 1962, 1977, and 1990; and high removals option projections to 2020.*

future plays out in the manner suggested by our assumptions. The projections, then, probably represent the high and low bounds within which the future forest may develop. Projections made for the first decade are more dependable than those for the last two decades because fast-changing political, economic, and market conditions can make long-range projections less reliable.

The total inventory of growing stock will continue to expand, as average tree size continues to increase, and as the volume of net growth continues to exceed the volume of removals. Inventories of individual species will differ in their rates of increase or decline based on their market demand, their growth rates, their place in the order of plant succession, their susceptibility to large-scale mortality, and other factors. Hardwoods will remain dominant. Inventories can be extended further by increased use of residues, tree tops, and limbs, the volumes of which are not included in growing-stock inventories. Inventories can also be stretched by greater use of short-log, rough, or rotten trees, which are all part of the nongrowing-stock resource. Substantially intensifying forest management (such as tree planting and stand improvement practices) could result in higher growth rates and larger inventories than those projected.

The Generic Environmental Impact Statement Study on Timber Harvesting and Forest Management in Minnesota (1994) prepared by Jaakko Pöyry Consulting, Inc., for the Minnesota Environmental Quality Board included a comprehensive assessment of three different levels of statewide timber harvesting. These harvest levels included: 4.0 million cords (316 million cubic feet); 4.9 million cords (387 million cubic feet), the level expected by 1995 if all announced or considered industry expansions are realized; and 7.0 million cords (553 million cubic feet), the estimated maximum sustainable annual volume from all tree species that would be available for harvest in 2000. (By comparison, the low option removals for 2020 is projected in this report to be 351 million cubic feet, and the high option removals is projected to be 472 million cubic feet.) One set of model runs was prepared assuming that all timberland in the State was available for timber harvest, and another set of model runs was made that constrained the number of acres that would be available for harvest, and accounted for anticipated changes in various forest management policies and procedures during the GEIS 50-year planning period and beyond. The set of unconstrained model runs indicated that all three harvest levels could be maintained during the period. The set of constrained runs indicated that the 4.0 and 4.9 million cord harvest levels could be maintained, but that the 7.0 million cord level could not be maintained in the long-term without a substantial increase in forest management and/or a reduction in the loss of timberland to other land uses (Jaakko Pöyry Consulting, Inc. 1994).

The area of the aspen forest type is likely to continue to decline somewhat further as mature and overmature aspen stands that contain small amounts of merchantable aspen are passed over for harvest and convert naturally to other forest types. The area of intensively managed aspen will likely remain constant, and could increase if sufficient area in stands of other types is converted to aspen and if management practices designed to increase aspen are implemented (fig. 22).

The future area of the oak-hickory type, which increased between 1977 and 1990 largely due to reversion of marginal agricultural lands, is more difficult to estimate. The wood of oaks, particularly that of red oaks, is in very high demand and is expected to be in even greater demand, yet oak regeneration can be difficult to establish unless specific silvicultural practices are followed. However, much of the oak resource in the State is held by many individual private owners, who differ in their interest in and understanding of the silvicultural needs of the species. Also, fast-changing national and international agricultural markets could make formerly marginal agricultural lands more economically attractive for growing agricultural products than for growing trees.

Figure 22.—*This former aspen sawtimber stand in St. Louis County was clearcut in the winter, but was regenerated by a carpet of aspen sprouts from the root mass by the end of the following summer when this photo was taken.*

Reduced harvests from public forest land, particularly the National Forests, in response to interest group pressures could increase the harvest from privately owned forests, to maintain or increase the previous level of timber products output. In turn, this could generate the need for an enlarged forestry extension and technical assistance effort, which could provide information to the State's estimated 130,000 private forest landowners to help them manage their lands more intensively, more profitably, and with greater attention to water, recreation, wildlife, and esthetic concerns.

Increasingly, Minnesota's forests, like those in the rest of the country, are coming under scrutiny from a public with diverse levels of interest in and understanding of issues related to the forest. Along with this scrutiny comes legal and political pressure to further certain goals for the forest. The State-funded GEIS Study mentioned earlier was in response to these kinds of political considerations. The future management of forest lands, particularly public forest lands, will undoubtedly be the subject of continuing vigorous debate.

Other pressures will also mold the State's forests in years to come. Rising environmental awareness and the desire for ecosystem-sensitive management will translate into management strategies that mitigate problems before they arise and that are "easy on the land." One of these strategies is the use of best management practices (BMP's), a set of guidelines developed to reduce the impact of timber harvesting and forest management activity on water quality, wetlands, and visual quality. Another is the modification of forest practices to minimize their impact on wildlife, such as retaining some forests well beyond the age when they could be harvested economically, retaining standing trees with

cavities, leaving large downed logs on the harvested site, and leaving wildlife travel corridors between parcels of fragmented forest land. Others are programs to reduce the loss of timberland to other land uses; strategies to leave more logging slash, particularly bark, small branches, and leaves, on the harvested site to retain soil nutrients; and techniques to reduce soil compaction and erosion on harvested sites. Still other programs will evolve and become accepted practice as we better understand what keeps ecosystems healthy and how to restore degraded ecosystems.

Non-commodity products from the forest—wildlife, recreation, biological diversity, esthetic beauty, and clean water—have become important, and will have a significant impact on the way forest lands are managed in the future. Consideration of the importance of these products will help commodity and non-commodity users of the forest find common ground as they seek to promote their own goals.

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APPENDIX

ACCURACY OF THE SURVEY

Forest Inventory and Analysis information is based on a sampling procedure designed to provide reliable statistics at the State and Survey Unit levels. Consequently, the reported figures are estimates only. A measure of reliability of these figures is given by sampling errors. These sampling errors mean that the chances are two out of three that if a 100-percent inventory had been taken, using the same methods, the results would have been within the limits indicated.

For example, the estimated growing-stock volume in the State in 1990, 15,133.1 million cubic feet, has a sampling error of ±0.71 percent (±107.4 million cubic feet). The growing-stock volume from a 100-percent inventory would be expected to fall between 15,025.7 and 15,240.5 million cubic feet (15,133.1 ± 107.4), there being a one in three chance that this is not the case.

The following tabulation shows the sampling errors for the Minnesota Forest Inventory:

Item	State totals	Sampling error
Growing stock	(Million cubic feet)	(Percent)
Volume (1990)	15,133.1	0.71
Average annual growth (1977-1989)	369.8	1.30
Average annual removals (1977-1989)	210.1	4.86
Sawtimber	(Million board feet)	
Volume (1990)	34,906.5	1.02
Average annual growth (1977-1989)	1,312.2	1.45
Average annual removals (1977-1989)	515.4	6.03
Timberland area (1990)	(Thousand acres) 14,723.2	0.36

As survey data are broken down into sections smaller than State totals, the sampling error increases. For example, the sampling error for timberland area in a particular county is higher than that for total timberland area in the State. This tabulation shows the sampling errors for State totals. To estimate sampling error for data smaller than State totals, use the following formula:

$$E = \frac{(SE)\sqrt{\text{(State total volume or area)}}}{\sqrt{\text{(Volume or area smaller than State total)}}}$$

where:

E = sampling error in percent
SE = State total error for volume or area

For example, to compute the error on the area of timberland in the aspen type for the State, proceed as follows:

The total area of aspen type in the State from table 3 = 5,055,000 acres

The total area of all timberland in the State from table 3 = 14,723,200 acres

The State total error for timberland area from the above tabulation = 0.36 percent

Using the above formula:

$$\text{Sampling error} = \frac{(0.0036)\sqrt{14{,}723{,}200}}{\sqrt{5{,}055{,}000}}$$

$$= \pm 0.0061 \text{ or } 0.61 \text{ percent}$$

COUNTY DATA

A standard FIA inventory is designed to provide sampling errors of no more than 3 percent per million acres of timberland or an overall error on Minnesota's nearly 15 million acres of about 0.8 percent. The State of Minnesota funded the collection of additional field data to reduce the sampling error by one-half. The goal was to provide a sampling error of less than 10 percent for total timberland area by county. This goal was achieved in the Aspen-Birch and Northern Pine Units and in most of the Central Hardwood Unit. It was not achieved in the Prairie Unit and in several counties in the Central Hardwood Unit. Sampling errors for area, volume, growth, and removals for both growing stock and sawtimber are shown in table 29, for each county in Minnesota.

The sampling error within a county depends on county size and total area of timberland. Many large, heavily forested counties in the State have sampling errors well below 5 percent. However, in counties where timberland area is less than 35,000 acres, the sampling error for the total area in timberland will generally exceed 10 percent. The sampling error for total timber volume in a reporting area containing 35,000 acres of timberland will be about 20 percent.

COMPARING MINNESOTA'S FIFTH INVENTORY WITH THE FOURTH INVENTORY

The following paragraphs highlight some of the procedural changes since the last inventory to assist the reader in analyzing data from this report:

A new volume estimation procedure was developed for the Lake States (see Survey Procedures section), and this procedure was used to compute the 1989 volumes and also to recompute the 1977 volume for growth calculations. Although the adjustment will differ by Survey Unit and species, the recomputed 1977 growing-stock and sawtimber volumes will generally be greater than those shown in the 1977 report.

Past surveys used only growing-stock trees to determine stand-size class. Current survey procedures require that stand-size class be determined on the basis of all live trees. Therefore, direct comparisons of current inventory data to old inventory data by stand-size class may be misleading.

The basic building block for estimating forest area and timber volume has been changed from the Survey Unit to the county. In the past, the statistics were developed at the Unit level and prorated back to the county on the basis of

photo-interpretation points. Direct development of county-level data helps users interested in more precise local data, but can make the outcome of comparisons with past estimates imprecise.

SURVEY PROCEDURES

The 1990 Minnesota survey used a growth model-enhanced, two-phase sample design. Using this sampling scheme and associated estimators is similar to sampling with partial replacement (SPR), in that a set of randomly located plots is available for remeasurement and a random set of new plots is established and measured. A significant feature of the new Minnesota design is stratification for disturbance on the old sample and use of a growth model to improve regression estimates made on old undisturbed forest plots (fig. 23). Detailed descriptions of the sampling and estimation procedures are presented by Hansen (1990). The growth model used in the Minnesota survey design was the Lake States Stand and Tree Evaluation and Modeling System (STEMS) (Belcher *et al.* 1982).

These were the major steps in the new survey design:

1. Aerial photography (Phase 1)

In this phase two sets of random points were located on current aerial photography. The first is a set of new photo plots and the second is a set of relocated old ground plot locations from the 1977 inventory. Photos used in the Aspen-Birch and Northern Pine Units were 1:58,000 scale color infrared National High Altitude Photo program (NHAP) prints purchased by the Minnesota Department of Natural Resources (DNR) from the U.S. Geological Survey. Aerial photos used in the Central Hardwood and Prairie Units were 1:40,000 black and white National Aerial Photography Program (NAPP) photos furnished by the Agricultural Stabilization and Conservation Service (ASCS). In addition, the DNR provided 35mm color prints at a scale of 1:15,840 of all of the 1977 ground plot locations. These 35mm prints were used in addition to the NHAP

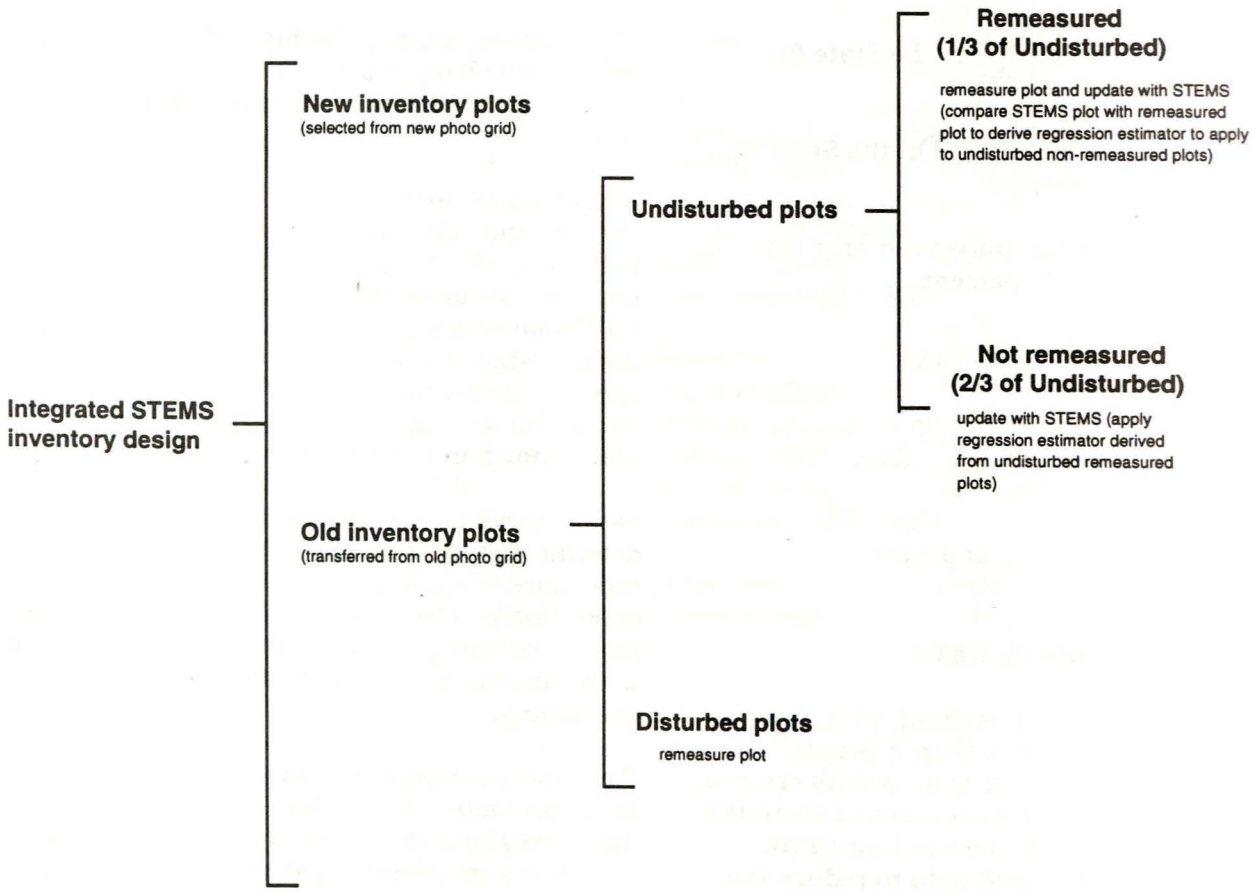
Integrated STEMS inventory design
New inventory plots
(selected from new photo grid)
Old inventory plots
(transferred from old photo grid)
Undisturbed plots
Remeasured
(1/3 of Undisturbed)
remeasure plot and update with STEMS (compare STEMS plot with remeasured plot to derive regression estimator to apply to undisturbed non-remeasured plots)
Not remeasured
(2/3 of Undisturbed)
update with STEMS (apply regression estimator derived from undisturbed remeasured plots)
Disturbed plots
remeasure plot

Figure 23.—*Overview of the Minnesota sample design.*

or NAPP prints to help detect disturbances in the 1977 ground plot locations. The dates of photography for each Survey Unit are given below. Dates of photography for individual counties can be found in their respective unit reports. Photo interpretation for the Aspen-Birch Unit and Northern Pine Unit was performed by the DNR. FIA photo interpreters classified the Central Hardwood and Prairie Units.

Unit	Date	
	NHAP/NAPP	35mm
Aspen-Birch	1981-1984	1986-1987
Northern Pine	1981-1985	1985-1989
Central Hardwoods	1976-1984	1988
Prairie	1978-1982	1988

The locations of the plots used in the 1977 inventory were transferred to these new photographs. The photographs were then assembled into township mosaics, and a systematic grid of 121 one-acre photo plots (each plot representing approximately 190.4 acres) was overlaid on each township mosaic. Each of these photo plots was examined by aerial photo interpretation specialists and classified stereoscopically based on land use. If trees were present, forest type and stand-size/density class were recorded. All of the 1977 ground plot locations were also examined for disturbance (such as logging, fire, and catastrophic mortality) with the aid of the 35mm photographs. After this examination, all the old "disturbed" sample locations and one-third of the old "undisturbed" forested plots were sent to the field for survey crews to verify the photo classification and to take further measurements. All photo plot locations for the 1990 inventory were examined and were classified as shown in the following tabulation.

Photo land class	Photo plots
Timberland	73,506
Reserved forest land	5,906
Other forest land	5,918
Questionable	2,876
Nonforest with trees	4,503
Nonforest without trees	174,934
Water	16,777
All classes	284,420

2. Plot measurements (Phase 2)

On plots classified as timberland, wooded pasture, or windbreak (at least 120 feet wide), a ground plot was established, remeasured, or modeled. Old plots sent to the field for remeasurement that could not be relocated were replaced with a new plot at the approximate location of the old one. Each ground plot consists of a 10-point cluster covering approximately 1 acre. At each point, trees 5.0 inches or more in d.b.h. were sampled on a 37.5 Basal Area Factor (BAF) variable-radius plot, and trees less than 5.0 inches d.b.h. were sampled on a 1/300-acre fixed-radius plot. The measurement procedures for the new and old sample locations were as follows:

a. New inventory plots

A systematic sample of the new photo plots was selected for field measurement. Ground plots were established, and measures of current classification such as land use, forest type, and ownership as well as size and condition of all trees on the plot were recorded. These locations were monumented for future remeasurement.

b. Old inventory plots

These plots were established, monumented, and measured as part of the 1977 field inventory. The procedures for these old plots were different from those for the new plots. Old plots were classed as "undisturbed" or "disturbed" in the aerial photo phase of the sampling process. All disturbed plots and a one-third sample of the undisturbed plots were remeasured to obtain estimates of current condition and changes since the last inventory. All trees measured on these plots in 1977 were remeasured or otherwise accounted for, and all new trees were identified and measured.

All sample plots that were forested at the time of the 1977 inventory and determined to be undisturbed until this inventory were projected to the current time using STEMS. This procedure gives projected estimates of current volume and growth for these undisturbed plots. The comparison of the projected and observed values on the one-third sample of the undisturbed forest plots that were remeasured provided local calibration data to adjust the projected values of the

undisturbed plots that were not remeasured. The adjustment procedure is a modified version of the method described by Smith (1983).

In the Aspen-Birch and Northern Pine Units, plots that were classified in Phase 1 as undisturbed nonforest were visually inspected from fixed wing aircraft to verify this classification. If the spotter felt the photo interpreter had misclassified the plot, the plot was ground checked by the field crew.

The old sample plots that were not forested in 1977 and were determined to be undisturbed until the current inventory (no evidence of conversion to another land use) were also subsampled (field checked) at the one-third rate. Any changes in land use to forest detected on these plots were used to adjust the two-thirds sample of these plots not field checked. The field check of these points in the Northern Pine Unit indicated that no adjustment was necessary.

The undisturbed forested plots that were not remeasured play a crucial role in the new survey design. These plots, after careful examination comparing past and current aerial photography, were determined to be undisturbed and had conditions that could be simulated by STEMS. The STEMS growth model was used to "grow" the old plot and tree data to produce an estimate of current data. Thus, these plots were treated as ground plots, even though they were never visited. The plot record for each modeled plot was sent to the field for verification of current ownership information.

All old plots classified as disturbed were sent to the field for remeasurement to assess and verify changes since the last inventory. Disturbance refers to any change on a plot that can be detected on aerial photos and that the STEMS growth processor cannot predict, such as catastrophic mortality, cutting, seedling stands, and land use change.

The estimation procedure for computing statistics from this sampling design was more complicated than the simple two-phase estimation procedure used in the past. In fact, this procedure yielded two independent samples, one coming from the new photo points and the other from the old photo points that are remeasured or modeled. The tabulation below summarizes the distribution of all ground plots for the new inventory design by type of plot.

3. Area estimates

Area estimates were made using two-phase estimation methods. In this type of estimation, a preliminary estimate of area by land use is made from the aerial photographs (Phase 1) and corrected by the plot measurements (Phase 2). A complete description of this estimation method is presented by Loetsch and Haller (1964).

4. Volume estimates

Estimates of volume per acre were made from the trees measured or modeled on the 10-point plots. Estimates of volume per acre were multiplied by the area estimates to obtain estimates of total volume. Net cubic foot volumes are based on a modification of the method presented by Hahn (1984) for use in the Lake States. For the Minnesota inventory, the merchantable height equation presented was used in conjunction with Stone's equation (see Appendix I in Hahn 1984) to estimate gross volume. This estimate was then corrected by species for variation in bark and cull volume to yield an estimate of net volume, using the coefficients presented in Hahn (1984).

Ground land use class	Old plots remeasured	Old plots updated	New plots	Total plots
Timberland	6,430	2,962	2,726	12,118
Reserved forest land	27	20	630	677
Other forest land	250	424	149	823
Nonforest with trees	462	92	127	681
Nonforest without trees	8,357	14,994	3,991	27,342
Water	583	1,050	685	2,318
Total	16,109	19,542	8,308	43,959

The Forest Service reports all board foot volume in International 1/4-inch rule. In Minnesota, the Scribner log rule is commonly used. Scribner log rule conversion factors were derived from full tree measurements taken throughout the Lake States (Michigan, Wisconsin, and Minnesota) and an equation developed by Wiant and Castenaeda (1977). The factors (multipliers) used to convert board foot International volumes to the Scribner rule are shown in the following tabulation:

D.b.h. (inches)	Scribner rule conversion factor	
	Softwoods	Hardwoods
9.0-10.9	0.7830	--
11.0-12.9	.8287	0.8317
13.0-14.9	.8577	.8611
15.0-16.9	.8784	.8827
17.0-18.9	.8945	.8999
19.0-20.9	.9079	.9132
21.0-22.9	.9168	.9239
23.0-24.9	.9240	.9325
25.0-26.9	.9299	.9396
27.0-28.9	.9321	.9454
29.0+	.9357	.9544

5. Growth and mortality estimates

On remeasured plots, estimates of growth and mortality per acre come from the remeasured diameters of trees and from observation of trees that died between inventories. Growth reported as the average net annual growth between the two inventories (1977 and 1990) is computed from data on remeasurement plots and modeled plots using methods presented by Van Deusen *et al.* (1986). Mortality is also average net annual for the remeasurement period. On new plots, where trees were not remeasured, estimates of growth and mortality were obtained by using STEMS to project the growth and mortality of trees for 1 year. Growth and mortality estimates for old undisturbed plots that were updated were derived in the same manner as estimates for remeasured plots. The STEMS growth model was adjusted by Survey Unit to meet local conditions, using data from the undisturbed remeasurement plots. As with volume, total growth and mortality estimates were obtained by multiplying the per acre estimates by area estimates. Current annual growth for 1989 was computed by using the adjusted STEMS model to grow all current inventory plots for 1 year.

6. Average annual removals estimates

Average annual growing-stock and sawtimber removals (1977 to 1989) were estimated only from the remeasured plots; new plots and STEMS-projected plots were not used to estimate removals. These estimates are obtained from trees measured in the last survey and cut or otherwise removed from the timberland base. Because remeasurement plots make up about one-half of the total ground plots, average annual removals estimates have greater sampling errors than volume and growth estimates.

TREE AND LOG GRADE

Log grades and/or tree grades were taken on approximately one-third of the sample plots in Minnesota. In Minnesota all sawtimber softwood sample trees were graded for quality and assigned a log grade. Log grades were also assigned to hardwood sawtimber trees in the Aspen-Birch and Northern Pine Units. Tree grades were assigned to hardwood sawtimber trees in the Prairie and Central Hardwood Units.

Log grades and tree grades are based on the classification of external characteristics as indicators of quality. The volume yield by log grade or tree grade for this sample was used to distribute the volume of the ungraded sample trees by species group. For example, in table 15, the volume in log grade 1 in the Aspen-Birch Unit (545,535 thousand board feet) represents all of the volume in that Unit in trees whose lowest log was given a log grade of 1.

Hardwood sawtimber trees in the Central Hardwood and Prairie Units were graded according to "Hardwood tree grades for factory lumber" (Hanks 1976). The best 12-foot section of the lowest 16-foot hardwood log was used for grading. Hardwood sawtimber trees that did not meet minimum tree grade specifications for grades 1 through 3 were assigned grade 4 according to Forest Service standard specifications for hardwood construction logs described in "A guide to hardwood log grading" (Rast *et al.* 1973).

Hardwood sawtimber trees in the Aspen-Birch and Northern Pine Units were graded according to "A guide to hardwood log grading." The best 12-foot section of the lowest 16-foot hardwood log, or the best 12-foot upper section if the butt log did not meet minimum log-grade standards, served as the basis for the grade.

Red pine and jack pine sawtimber trees were graded based on specifications described in "Forest Service log grades for southern pines" (Campbell 1964). White pine and other softwood sawtimber trees were graded according to specifications described by Ostrander and Brisbin (1971). For all softwoods, the first merchantable 16-foot log, or shorter lengths down to 12 feet, was used for grading.

Hardwood tree grade for factory lumber [a] (used in Central Hardwood and Prairie Units)

Grade factor	Tree grade 1	Tree grade 2	Tree grade 3
Length of grading zone (feet)	Butt 16	Butt 16	Butt 16
Length of grading section [b] (feet)	Best 12	Best 12	Best 12
D.b.h., minimum (inches)	16[c]	13	11
Diameter, minimum inside bark at top of grading section (inches)	13[c] 16 20	11[d] 12	8
Clear cuttings (on the three best faces)[e]			
Length, minimum (feet)	7 5 3	3 3	2
Number on face (maximum)	2	2 3	f
Yield in face length (minimum)	5/6	4/6	3/6
Cull deduction (including crook and sweep, but excluding shake) maximum within grading section (percent)	9	9[g]	50

[a] Hanks (1976)

[b] Whenever a 14- or 16-foot section of the butt 16-foot log is better than the best 12-foot section, the grade of the longer section will become the grade of the tree. This longer section, when used, is the basis for determining the grading factors such as diameter and cull deduction.

[c] In basswood and ash, d.i.b. at top of grading section must be 12 inches and d.b.h. must be 15 inches.

[d] Grade 2 trees can be 10 inches d.i.b. at top of grading section if they otherwise meet surface requirements for small grade 1's.

[e] A clear cutting is a portion of a face free of defects, extending the width of the face. A face is one-fourth of the surface of the grading section as divided lengthwise.

[f] Unlimited.

[g] Fifteen percent crook and sweep or 40 percent total cull deduction are permitted in grade 2 trees, if size and surface of grading section qualify as grade 1. If rot shortens the required clear cuttings to the extent of dropping the butt log to grade 2, do not drop the tree's grade to 3 unless the cull deduction for rot is greater than 40 percent.

Forest Service standard grades for hardwood factory saw logs [a] (used in Aspen-Birch and Northern Pine Units)

Grading Factors		Log Grades							
		Log grade 1			Log grade 2				Log grade 3
Position in tree		Butts only	Butts & uppers		Butts & uppers				Butts & uppers
Scaling diameter, inches		13-15[b]	16-19	20+	11+[c]		12+		8+
Length without trim, feet			10+		10 +	8-9	10-11	12+	8+
Required clear cuttings [d] of each of three best faces[e]	Min. length, feet	7	5	3	3	3	3	3	2
	Max. number	2	2	2	2	2	2	3	No limit
	Min. proportion of log length required in clear cutting	5/6	5/6	5/6	2/3	3/4	2/3	2/3	1/2
Maximum sweep & crook allowance	For logs with less than one-fourth of end in sound defects		15 percent			30 percent			50 percent
	For logs with more than one-fourth of end in sound defects		10 percent			20 percent			35 percent
Maximum scaling deduction			40 percent[f]			50 percent[g]			50 percent

[a] Rast *et al.* (1973)

[b] Ash and basswood butts can be 12 inches if they otherwise meet requirements for small #1's.

[c] Ten-inch logs of all species can be #2 if they otherwise meet requirements for small #1's.

[d] A clear cutting is a portion of a face, extending the width of the face, that is free of defects.

[e] A face is one-fourth of the surface of the log as divided lengthwise.

[f] Otherwise #1 logs with 41- to 60-percent deductions can be #2.

[g] Otherwise #2 logs with 51- to 60-percent deductions can be #3.

Forest Service standard specifications for hardwood construction logs (tie and timber logs) [a, b]

Position in tree	Butts and uppers
Min. diameter, small end	8 inches +
Min. length without trim	8 feet
Clear cuttings	No requirements
Sweep allowance	One-fourth of the diameter at the small end for each 8 feet of length.
Sound surface defects:	
Single knots	Any number, if no one knot has an average diameter above the callus in excess of one-third of the log diameter at point of occurrence.
Whorled knots	Any number, if the sum of knot diameters above the callus does not exceed one-third of the log diameter at point of occurrence.
Holes	Any number, provided none has a diameter over one-third of the log diameter at point of occurrence and none extends more than 3 inches into included timber[c].
Unsound surface defects:	Same requirements as for sound defects if they extend into included timber. No limit if they do not.

[a] Rast *et al.* (1973).

[b] These specifications are minimum for the class. If, from a group of logs, factory logs are selected first, thus leaving only nonfactory logs from which to select construction logs, then the quality range of the construction logs so selected is limited, and the class may be considered a grade. If selection for construction logs is given first priority, it may be necessary to subdivide the class into grades.

[c] Included timber is always square, and dimension is judged from small end.

Eastern white pine saw log grade specifications [a]

Grading Factor	Log Grade 1	Log Grade 2	Log Grade 3	Log Grade 4
1. Minimum scaling diameter (inches)	14 [b]	6	6	6
2. Minimum log length (feet)	10 [c]	8	8	8
3. Maximum weevil injury (number)	None	None	2 Injuries [d]	No Limit
4. Minimum face requirements	Two full length or four 50% [e] length good faces (in addition, log knots on balance of faces shall not exceed size limits of grade logs.)	NO GOOD FACES REQUIRED Maximum diameter of log knots on three best faces: SOUND RED KNOTS not to exceed 1/6 scaling diameter and 3 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/12 scaling diameter and 1 1/2 inch maximum.	SOUND RED Knots not to exceed 1/3 scaling diameter and 5 inch maximum. DEAD OR BLACK KNOTS including overgrown knots not to exceed 1/6 scaling diameter and 2 1/2 inch maximum.	Includes all logs not qualifying for No.3 or better and have at least 1/3 of their gross volume in sound wood suitable for manufacture into standard lumber.
5. Maximum sweep or crook allowance (%)	20	30	40	66 2/3
6. Maximum total scaling deduction (%)	50	50	50	66 2/3

AFTER THE TENTATIVE LOG GRADE IS ESTABLISHED FROM FACE EXAMINATION, THE LOG WILL BE REDUCED IN GRADE WHENEVER THE FOLLOWING DEFECTS ARE EVIDENT.

7. Conks, punk knots, and pine borer damage on bark surface [f].
   Degrade one grade if present on one face.
   Degrade two grades if present on two faces.
   Degrade three grades if present on three or more faces.

8. Log end defects: red rot, ring shake, heavy stain and pine borer damage outside the heart center of log [e].
   Consider log as having a total of 8 quarters (4 on each end) and degrade as indicated.
   Degrade one grade if present in 2 quarters of log ends.
   Degrade two grades if present in 3 or 4 quarters of log ends.
   Degrade three grades if present in 5 or more quarters of log ends.

[a] Ostrander and Brisbin (1971)

[b] Twelve- and thirteen-inch logs with four full length good faces are acceptable.

[c] Eight-foot logs with four full length good faces are acceptable.

[d] Eight-foot grade 3 logs limited to one weevil injury.

[e] Minimum 50 percent length good face must be at least 6 feet.

[f] Factors 7 and 8 are not cumulative (total degrade based on more serious of the two). No log to be degraded below grade 4 if net scale is at least one-third of gross scale.

Log grades for jack pine and red pine [a]

Grade 1: Trees with three or four clear faces on the 16-foot grading section.[b]
Grade 2: Trees with one or two clear faces on the 16-foot grading section.
Grade 3: Trees with no clear faces on the 16-foot grading section.

After the tentative grade is established from above, the tree will be reduced one grade for each of the following, except that no tree can be reduced below grade 3, provided the total scaling deductions for sweep and/or rot do not exceed two-thirds of the gross scale of the tree.

Sweep. Degrade any tentative grade 1 or 2 tree one grade if sweep in the lower 12 feet of grading sections amounts to 3 or more inches and equals or exceeds one-fourth of the diameter at breast height.

Heart rot. Degrade any tentative grade 1 or 2 tree one grade if conk, punk knots, massed hyphae, or other evidence of advanced heart rot is found anywhere on the main tree stem.

[a] Campbell (1964)

[b] A face is one-fourth of the circumference in width extending full length of the grading section. Clear faces are those free of: knots measuring more than one-half-inch in diameter, overgrown knots of any size, and holes more than one-quarter-inch in diameter. Faces may be rotated to obtain the maximum number of clear ones on the grading section.

Log grades for all other softwood logs

Grade 1

1. Trees must be 16 inches in diameter or larger, grading section 12 feet in length or longer, and with deduction for defect not over 30 percent of gross scale.
2. Trees must be at least 75 percent clear on each of three faces.
3. All knots outside clear cutting must be sound and not more than 2-1/2 inches in size.

Grade 2

1. Trees must be 12 inches in diameter or larger, grading section 12 feet in length or longer, and with a net scale after deduction for defect of at least 50 percent of the gross scale deducted for defect.
2. Trees must be at least 50 percent clear on each of three faces or 75 percent clear on two faces.

Grade 3

1. Trees must be 6 inches in diameter or larger, grading section 12 feet in length or longer, and with a net scale after deduction for defect of at least 50 percent of the gross contents of the log.

Note: Diameters are diameter inside bark (d.i.b.) at small end of grading section.

Percent clear refers to percent clear in one continuous section.

METRIC EQUIVALENTS OF UNITS USED IN THIS REPORT

1 acre = 4,046.86 square meters or 0.405 hectare.
1,000 acres = 405 hectares.
1 cubic foot = 0.0283 cubic meter.
1 foot = 30.48 centimeters or 0.3048 meter.
1 inch = 25.4 millimeters, 2.54 centimeters, or 0.0254 meter.
1 pound = 0.454 kilograms.
1 ton = 0.907 metric tons.

TREE SPECIES GROUPS IN MINNESOTA

Species names are based on Little (1981).

SOFTWOODS

Eastern white pine ..... *Pinus strobus*
Red pine ..... *Pinus resinosa*
Jack pine ..... *Pinus banksiana*
White spruce ..... *Picea glauca*
Black spruce ..... *Picea mariana*
Balsam fir ..... *Abies balsamea*
Tamarack ..... *Larix laricina*
Northern white-cedar ..... *Thuja occidentalis*
Other softwoods
- Eastern redcedar ..... *Juniperus virginiana*
- Scotch pine ..... *Pinus sylvestris*
- Ponderosa pine ..... *Pinus ponderosa*

HARDWOODS

Select white oaks[6]
- White oak ..... *Quercus alba*
- Bur oak ..... *Quercus macrocarpa*
- Swamp white oak ..... *Quercus bicolor*

Select red oaks[6]
- Northern red oak ..... *Quercus rubra*

Other red oaks[6]
- Northern pin oak ..... *Quercus ellipsoidalis*
- Black oak ..... *Quercus velutina*

Hickories[6]
- Shagbark hickory ..... *Carya ovata*
- Bitternut hickory ..... *Carya cordiformis*

Hard maples[6]
- Black maple ..... *Acer nigrum*
- Sugar maple ..... *Acer saccharum*

Soft maples[7]
- Red maple ..... *Acer rubrum*
- Silver maple ..... *Acer saccharinum*

Ashes
- White ash[6] ..... *Fraxinus americana*
- Black ash[7] ..... *Fraxinus nigra*
- Green ash[6] ..... *Fraxinus pennsylvanica*

Balsam poplar[7] ..... *Populus balsamifera*

Aspens[7]
- Bigtooth aspen ..... *Populus grandidentata*
- Quaking aspen ..... *Populus tremuloides*

Cottonwood[7] ..... *Populus deltoides*
Basswood[7] ..... *Tilia americana*
Black walnut[6] ..... *Juglans nigra*
Black cherry[7] ..... *Prunus serotina*
Butternut[7] ..... *Juglans cinerea*

Elms
- American elm[7] ..... *Ulmus americana*
- Siberian elm[7] ..... *Ulmus pumila*
- Slippery elm[7] ..... *Ulmus rubra*
- Rock elm[6] ..... *Ulmus thomasii*

Birches[7]
- Yellow birch ..... *Betula alleghaniensis*
- River birch ..... *Betula nigra*
- Paper birch ..... *Betula papyrifera*

Hackberry[7] ..... *Celtis occidentalis*
Black willow[7] ..... *Salix nigra*

Other hardwoods
- Boxelder[7] ..... *Acer negundo*
- Black locust[6] ..... *Robinia pseudoacacia*
- Red mulberry[7] ..... *Morus rubra*
- Kentucky coffeetree[6] ..... *Gymnocladus dioicus*

Noncommercial species
- Striped maple ..... *Acer pensylvanicum*
- Mountain maple ..... *Acer spicatum*
- Ailanthus ..... *Ailanthus altissima*
- American hornbeam ..... *Carpinus caroliniana*
- Hawthorn ..... *Crataegus* spp.
- Apple ..... *Malus* spp.
- Eastern hophornbeam ..... *Ostrya virginiana*
- Pincherry ..... *Prunus pensylvanica*
- Wild plum ..... *Prunus* spp.
- Chokecherry ..... *Prunus virginiana*
- Peachleaf willow ..... *Salix amygdaloides*
- American mountain ash ..... *Sorbus americana*

DEFINITION OF TERMS

Average annual mortality of growing stock.—The average cubic foot volume of sound wood in growing-stock trees that died. Average annual mortality is the average for the years between inventories (1977 to 1990 in this report).

Average annual mortality of sawtimber.—The average board foot volume of sound wood in sawtimber trees that died. Average annual

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[6] *This species or species group is considered a hard hardwood, with an average specific gravity greater than or equal to 0.50.*

[7] *This species or species group is considered a soft hardwood, with an average specific gravity of less than 0.50.*

mortality is the average for the years between inventories (1977 to 1990 in this report).

Average annual removals from growing stock.—The average net growing-stock volume in growing-stock trees removed annually for roundwood forest products, in addition to the volume of logging residues, and the volume of other removals. Average annual removals of growing stock are the average for the years between inventories (1977 to 1989 in this report) and are based on information obtained from remeasurement plots (see Survey Procedures in Appendix).

Average annual removals from sawtimber.—The average net board foot sawtimber volume of live sawtimber trees removed annually for roundwood forest products, in addition to the volume of logging residues, and the volume of other removals. Average annual removals of sawtimber are the average for the years between inventories (1977 to 1989 in this report) and are based on information obtained from remeasurement plots (see Survey Procedures in Appendix).

Average net annual growth of growing stock.—The annual change in cubic foot volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes. Average net annual growing stock is the average for the years between inventories (1977 to 1989 in this report).

Average net annual growth of sawtimber.—The annual change in the board foot volume of live sawtimber trees, and the total volume of trees reaching sawtimber size, less volume losses resulting from natural causes. Average net annual growth of sawtimber is the average for the years between inventories (1977 to 1989 in this report).

Basal area.—The area in square feet of the cross section at breast height of a single tree. When the basal area of all trees in a stand is summed, the result is usually expressed as square feet of basal area per acre.

Biomass.—The aboveground volume of all live trees (including bark but excluding foliage) reported in green tons (i.e., green weight). Biomass has four components:

Bole.—Biomass of a tree from 1 foot above the ground to a 4-inch top outside bark.

Tops and limbs.—Total biomass of tree from a 1-foot stump minus the bole.

1- to 5-inch trees.—Total aboveground biomass of a tree from 1 to 5 inches in diameter at breast height.

Stump.—Biomass of a tree 5 inches d.b.h. and larger from the ground to a height of 1 foot.

Commercial species.—Tree species presently or prospectively suitable for industrial wood products. (Note: Excludes species of typically small size, poor form, or inferior quality such as hophornbeam, osage-orange, and redbud.)

Cord.—One standard cord is 128 cubic feet of stacked wood, including bark and air space. Cubic feet can be converted to solid wood standard cords by dividing by 79.

Corporate.—Lands owned by a private corporation not in the business of operating primary wood-using plants.

County and municipal land.—Land owned by counties and local public agencies or municipalities, or land leased to these governmental units for 50 years or more.

Cropland.—Land under cultivation within the last 24 months; including cropland harvested, crop failures, cultivated summer fallow, idle cropland used only for pasture, orchards, and land in soil improvement crops, but excluding land cultivated in developing improved pasture.

Cull.—Portions of a tree that are unusable for industrial wood products because of rot, missing or dead material, form, or other defect.

Current annual growth of growing stock.—The annual change in volume of sound wood in live sawtimber and poletimber trees, and the total volume of trees entering these classes through ingrowth, less volume losses resulting from natural causes, reported for a single year (1989 in this report). Current growth is based on an estimate of the current annual increment of each growing-stock tree in the inventory.

Current annual growth of sawtimber.—The annual change in the volume of live sawtimber trees, and the total volume of trees reaching sawtimber size, less volume losses resulting from

natural causes, reported for a single year (1989 in this report). Current growth is based on an estimate of the current annual increment of each growing-stock tree in the inventory.

Current annual removals from growing stock.—The current net growing-stock volume in growing-stock trees removed annually for roundwood forest products, in addition to the volume in logging residues, and the volume in other removals. Current annual removals of growing stock are reported for a single year (1988 in this report); they are based on a survey of primary wood processing mills to determine removals for products and on information from remeasurement plots (see Survey Procedures in Appendix) to determine removals due to land use change.

Current annual removals from sawtimber.—The current net board foot sawtimber volume of live sawtimber trees removed annually for roundwood forest products, in addition to the volume in logging residues, and the volume in other removals. Current annual removals of sawtimber are reported for a single year (1988 in this report); they are based on a survey of primary wood processing mills to determine removals for products and on information from remeasurement plots (see Survey Procedures in Appendix) to determine removals due to land use change.

Diameter class.—A classification of trees based on diameter outside bark, measured at breast height 4.5 feet above the ground. (Note d.b.h. is the common abbreviation for diameter at breast height.) Two-inch diameter classes are commonly used in Forest Inventory and Analysis, with the even inch the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Diameter at breast height (d.b.h.).—The outside bark diameter at 4.5 feet (1.37m) above the forest floor on the uphill side of the tree. For determining breast height, the forest floor includes the duff layer that may be present, but does not include unincorporated woody debris that may rise above the ground line.

Farm.—Any place from which $1,000 or more of agricultural products were produced and sold during the year.

Farmer-owned land.—See individual private land.

Forest industry land.—Land owned by companies or individuals operating primary wood-using plants.

Forest land.—Land at least 16.7 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. (Note: Stocking is measured by comparing specified standards with basal area and/or number of trees, age or size, and spacing.) The minimum area for classification of forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must have a crown width of at least 120 feet to qualify as forest land. Unimproved roads and trails, streams, or other bodies of water or clearings in forest areas shall be classed as forest if less than 120 feet wide. (See Tree, Land, Timberland, Reserved forest land, Other forest land, Stocking, and Water.)

Forest type.—A classification of forest land based on the species forming a plurality of live tree stocking. Major forest types in the State are:

Jack pine.—Forests in which jack pine comprises a plurality of the stocking. (Common associates include eastern white pine, red pine, aspen, birch, and maple.)

Red pine.—Forests in which red pine comprises a plurality of the stocking. (Common associates include eastern white pine, jack pine, aspen, birch, and maple.)

White pine.—Forests in which eastern white pine comprises a plurality of the stocking. (Common associates include red pine, jack pine, aspen, birch, and maple.)

Balsam fir.—Forests in which balsam fir and white spruce comprise a plurality of stocking with balsam fir the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)

White spruce.—Forests in which white spruce and balsam fir comprise a plurality of the stocking with white spruce the most common. (Common associates include aspen, maple, birch, northern white-cedar, and tamarack.)

Black spruce.—Forests in which swamp conifers comprise a plurality of the stocking with black spruce the most common. (Common associates include tamarack and northern white-cedar.)

Northern white-cedar.—Forests in which swamp conifers comprise a plurality of the stocking with northern white-cedar the most

common. (Common associates include tamarack and black spruce.)

Tamarack.—Forests in which swamp conifers comprise a plurality of the stocking with tamarack the most common. (Common associates include black spruce and northern white-cedar.)

Oak-hickory.—Forests in which northern red oak, white oak, bur oak, or hickories, singly or in combination, comprise a plurality of the stocking. (Common associates include jack pine, elm, and maple.)

Elm-ash-soft maple.—Forests in which lowland elm, ash, red maple, silver maple, and cottonwood, singly or in combination, comprise a plurality of the stocking. (Common associates include birches, spruce, and balsam fir.)

Maple-basswood.—Forests in which sugar maple, basswood, yellow birch, upland American elm, and red maple, singly or in combination, comprise a plurality of the stocking. (Common associates include white pine, elm, and basswood.)

Aspen.—Forests in which quaking aspen or bigtooth aspen, singly or in combination, comprise a plurality of the stocking. (Common associates include balsam poplar, balsam fir, and paper birch.)

Paper birch.—Forests in which paper birch comprises a plurality of the stocking. (Common associates include maple, aspen, and balsam fir.)

Balsam poplar.—Forests in which balsam poplar comprises a plurality of the stocking. (Common associates include aspen, elm, and ash.)

Growing-stock tree.—A live tree of commercial species that meets specified standards of size, quality, and merchantability. (Note: Excludes rough, rotten, and dead trees.)

Growing-stock volume.—Net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4.0-inch top diameter outside bark of the central stem or to the point where the central stem breaks into limbs.

Hard hardwoods.—Hardwood species with an average specific gravity greater than 0.50 such as oaks, hard maple, hickories, and ash.

Hardwoods.—Dicotyledonous trees, usually broad-leaved and deciduous. (See Soft hardwoods and Hard hardwoods.)

Improved pasture.—Land currently improved for grazing by cultivating, seeding, irrigating, or clearing trees or brush and less than 16.7 percent stocked with trees.

Indian land.—Land held in trust by the United States for tribes or individual Indians.

Individual private land.—Privately owned land not owned by forest industry. This class includes the formerly used Farmer and Miscellaneous private classes.

Industrial wood.—All roundwood products except residential fuelwood.

Land.—*(a) Bureau of the Census.* Dry land and land temporarily or partly covered by water such as marshes, swamps, and river flood plains (omitting tidal flats below mean high tide); streams, sloughs, estuaries, and canals less than one-eighth of a statute mile wide; and lakes, reservoirs, and ponds less than 40 acres in area.

(b) Forest Inventory and Analysis. The same as the Bureau of the Census, except minimum width of streams, etc., is 120 feet and minimum size of lakes, etc., is 1 acre.

Live trees.—Growing-stock, rough, and rotten trees 1.0 inch d.b.h. and larger.

Log grade.—A log classification based on external characteristics as indicators of quality or value. Log grade was assigned to a sample of softwood sawtimber trees throughout the State and to a sample of hardwood sawtimber trees in the Aspen-Birch and Northern Pine Units during the 1990 inventory. Also see Tree grade. (See Appendix for specific grading factors used.)

Logging residue.—The unused portions of trees cut or killed by logging.

Marsh.—Nonforest land that characteristically supports low, generally herbaceous or shrubby vegetation, and that is intermittently covered with water.

Merchantable.—Refers to a pulpwood or saw-log section that meets pulpwood or saw log specifications, respectively.

Miscellaneous Federal land.—Federal land other than National Forest and land administered by the Bureau of Land Management or Bureau of Indian Affairs.

Miscellaneous private land.—(See Individual private land.)

National Forest land.—Federal land that has been legally designated as National Forest or purchase units, and other land administered by the USDA Forest Service.

Net volume.—Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Noncommercial species.—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land.—Land that has never supported forests, and land formerly forested where use for timber management is precluded by development for other uses. (Note: Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining clearings, powerline clearings of any width, and 1- to 40-acre areas of water classified by the Bureau of the Census as land. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide and more than 1 acre in area to qualify as nonforest land.)

a. Nonforest land without trees.—Nonforest land with no live trees present.

b. Nonforest land with trees.—Nonforest land with one or more trees per acre at least 5 inches d.b.h.

Nonstocked land.—Timberland less than 16.7 percent stocked with all live trees.

Other forest land.—Forest land not capable of producing 20 cubic feet per acre per year of industrial wood crops under natural conditions and not associated with urban or rural development. Many of these sites contain tree species that are not currently utilized for industrial wood production or trees of poor form, small size, or inferior quality that are unfit for industrial products. Unproductivity may be the result of adverse site conditions such as sterile soil, dry climate, poor drainage, high elevation, and rockiness. This land is not withdrawn from timber utilization.

Other removals.—Growing-stock trees removed but not utilized for products, or trees left standing but "removed" from the timberland classification by land use change. Examples are removals from cultural operations such as timber stand improvement work, land clearing, and changes in land use.

Ownership size class.—The amount of timberland owned by one owner, regardless of the number of parcels.

Ownership tenure.—The length of time a property has been held by the owner.

Pasture.—Land presently used for grazing or under cultivation to develop grazing.

Physiographic class.—A measure of soil and water conditions that affect tree growth on a site. The physiographic classes are:

Xeric sites.—Very dry soils where excessive drainage seriously limits both growth and species occurrence. Example: sandy jack pine plains.

Xeromesic sites.—Moderately dry soils where excessive drainage limits growth and species occurrence to some extent. Example: dry oak ridge.

Mesic sites.—Deep, well-drained soils. Growth and species occurrence are limited only by climate. Example: well-drained terraces of loamy soil.

Hydromesic sites.—Moderately wet soils where insufficient drainage or infrequent flooding limits growth and species occurrence to some extent. Example: moderately drained bottomland hardwood sites.

Hydric sites.—Very wet sites where excess water seriously limits both growth and species occurrence. Example: frequently flooded river bottoms and black spruce swamps.

Plant byproducts.—Plant residues used for products such as mulch, pulp chips, and fuelwood.

Plantation.—An artificially reforested area sufficiently productive to qualify as timberland. The planted species is not necessarily predominant. Christmas tree plantations, which are considered reserved forest land, are not included.

Plant residues.—Wood and bark materials generated at manufacturing plants during production of other products.

Poletimber stand.—(See Stand-size class.)

Poletimber tree.—A live tree of commercial species at least 5.0 inches d.b.h., but smaller than sawtimber size.

Potential productivity class.—A classification of forest land in terms of inherent capacity to grow crops of industrial wood. The class identifies the potential growth in merchantable cubic feet/acre/year at culmination of mean annual increment of fully stocked natural stands.

Reserved forest land.—Forest land withdrawn from timber utilization through statute, administrative regulation, designation, or exclusive use for Christmas tree production, as indicated by annual shearing.

Rotten tree.—Live trees of commercial species that do not contain at least one 12-foot saw log or two saw logs 8 feet or longer, now or prospectively, and/or do not meet regional specifications for freedom from defect primarily because of rot; that is, when more than 50 percent of the cull volume in a tree is rotten.

Rough tree.—(a) Live trees of commercial species that do not contain at least one merchantable 12-foot saw log or two saw logs 8 feet or longer, now or prospectively, and/or do not meet regional specifications for freedom from defect primarily because of roughness or poor form, and (b) all live trees of noncommercial species.

Roundwood products.—Logs, bolts, or other round sections (including chips from roundwood) cut from trees for industrial or consumer uses. (Note: Includes saw logs, veneer logs, and bolts; cooperage logs and bolts; pulpwood; fuelwood; pilings; poles; posts; hewn ties; mine timbers; and various other round, split, or hewn products.)

Salvable dead tree.—A standing or down dead tree considered merchantable by regional standards.

Sapling.—A live tree 1.0 to 5.0 inches d.b.h.

Sapling-seedling stand.—(See Stand-size class.)

Saw log.—A log meeting minimum standards of diameter, length, and defect, including logs at least 8 feet long, sound and straight and with a minimum diameter outside bark (d.o.b.) for softwoods of 7.0 inches (9.0 inches for hardwoods) or other combinations of size and defect specified by regional standards.

Saw-log portion.—That part of the bole of sawtimber trees between the stump and the saw-log top.

Saw-log top.—The point on the bole of sawtimber trees above which a saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber stand.—(See Stand-size class.)

Sawtimber tree.—A live tree of commercial species containing at least a 12-foot saw log or two noncontiguous saw logs 8 feet or longer, and meeting regional specifications for freedom from defect. Softwoods must be at least 9.0 inches d.b.h. Hardwoods must be at least 11.0 inches d.b.h.

Sawtimber volume.—Net volume of the saw-log portion of live sawtimber in board feet, International 1/4-inch rule (unless specified otherwise), from stump to a minimum 7 inches top diameter outside bark (d.o.b.) for softwoods and a minimum 9 inches top d.o.b. for hardwoods.

Seedling.—A live tree less than 1.0 inch d.b.h. that is expected to survive. Only softwood seedlings more than 6 inches tall and hardwood seedlings more than 1 foot tall are counted.

Short-log (rough tree).—A sawtimber-size tree of commercial species that contains at least one merchantable 8- to 11-foot saw log but not a 12-foot saw log.

Shrub.—A woody, perennial plant differing from a perennial herb in its persistent and woody stem(s) and less definitely from a tree in its lower stature and/or the general absence of a well-defined main stem. For this report, shrubs were separated somewhat arbitrarily into tall and low shrubs as follows:

Tall shrubs.—Shrubs normally taller than 1.6 to 3.2 feet (0.5 to 1.0 meter)

Low shrubs.—Shrubs normally shorter than 1.6 to 3.2 feet (0.5 to 1.0 meter). (Woody perennial vines, such as grape, were included with low shrubs.)

Shrub and tree seedling biomass.—The total aboveground weight of trees less than 1.0 inch in diameter and all shrubs.

Site index.—An expression of forest site quality based on the height of a free-growing dominant or codominant tree of a representative species in the forest type at age 50.

Soft hardwoods.—Hardwood species with an average specific gravity less than 0.50, such as cottonwood, red maple, basswood, and willow.

Softwoods.—Coniferous trees, usually evergreen, having needles or scale-like leaves.

Stand.—A group of trees on a minimum of 1 acre of forest land that is stocked by forest trees of any size.

Stand-age class.—A classification based on age of the main stand. Main stand refers to trees of the dominant forest type and stand-size class.

Stand-size class.—A classification of stocked (see Stocking) forest land based on the size class of live trees on the area; that is, sawtimber, poletimber, or seedlings and saplings.

a. Sawtimber stands.—Stands with half or more of live stocking in sawtimber or poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

b. Poletimber stands.—Stands with half or more live stocking in poletimber and/or sawtimber trees, and with poletimber stocking exceeding that of sawtimber.

c. Sapling-seedling stands.—Stands with more than half of the live stocking in saplings and/or seedlings.

State land.—Land owned by the State of Minnesota or leased to it for 50 years or more.

Stocking.—The degree of occupancy of land by live trees, measured by basal area and/or the number of trees in a stand by size or age and spacing, compared to the basal area and/or number of trees required to fully utilize the growth potential of the land; that is, the stocking standard.

A stocking percent of 100 indicates full utilization of the site and is equivalent to 80 square feet of basal area per acre in trees 5.0 inches d.b.h. and larger. In a stand of trees less than 5 inches d.b.h., a stocking percent of 100 would indicate that the present number of trees is sufficient to produce 80 square feet of basal area per acre when the trees reach 5 inches d.b.h.

Stands are grouped into the following stocking classes:

Overstocked stands.—Stands in which stocking of live trees is 133.0 percent or more.

Fully stocked stands.—Stands in which stocking of live trees is from 100.0 to 132.9 percent.

Medium stocked stands.—Stands in which stocking of live trees is from 60.0 to 99.9 percent.

Poorly stocked stands.—Stands in which stocking of live trees is from 16.7 to 59.9 percent.

Nonstocked areas.—Timberland on which stocking of live trees is less than 16.7 percent.

Timber products output.—All timber products cut from roundwood and byproducts of wood manufacturing plants. Roundwood products include logs, bolts, or other round sections cut from growing-stock trees, cull trees, salvable dead trees, trees on nonforest land, noncommercial species, sapling-size trees, and limbwood. Byproducts from primary manufacturing plants include slabs, edging, trimmings, miscuts, sawdust, shavings, veneer cores and clippings, and screenings of pulpmills that are used as pulpwood chips or other products.

Timberland.—Forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development. Currently inaccessible and inoperable areas are included.

Tree.—A woody plant usually having one or more perennial stems, a more or less definitely formed crown of foliage, and a height of at least 12 feet at maturity.

Tree biomass.—The total aboveground weight (including the bark but excluding the foliage) of

all trees from 1 to 5 inches in d.b.h., and the total aboveground weight (including the bark but excluding the foliage) from a 1-foot stump for trees more than 5 inches in diameter.

Tree grade.—A tree classification based on external characteristics as indicators of quality or value that may be used to estimate the lumber grade yield. Tree grade was assigned to a sample of hardwood sawtimber trees in the Central Hardwood and Prairie Units during the 1990 inventory. Also see Log grade. (See Appendix for specific grading factors used.)

Tree size class.—A classification of trees based on diameter at breast height, including sawtimber trees, poletimber trees, saplings, and seedlings.

Upper stem portion.—That part of the bole of sawtimber trees above the saw-log top to a minimum top diameter of 4.0 inches outside bark or to the point where the central stem breaks into limbs.

Urban and other areas. —Areas within the legal boundaries of cities and towns; suburban areas developed for residential, industrial, or recreational purposes; school yards; cemeteries; roads; railroads; airports; beaches; powerlines and other rights-of-way; or other nonforest land not included in any other specified land use class.

Urban forest land.—Land that would otherwise meet the criteria for timberland, but is in an urban-suburban area surrounded by commercial, industrial, or residential development and not likely to be managed for the production of industrial wood products on a continuing basis. Wood removed would be for land clearing, fuelwood, or esthetic purposes. Such forest land may be associated with industrial, commercial, residential subdivision, industrial parks, golf course perimeters, airport buffer strips, and public urban parks that qualify as forest land.

Water.—*(a) Bureau of the Census.*—Permanent inland water surfaces, such as lakes, reservoirs, and ponds at least 40 acres in area; and streams, sloughs, estuaries, and canals at least one-eighth of a statute mile wide.

(b) Noncensus.—Permanent inland water surfaces, such as lakes, reservoirs, and ponds from 1 to 39.9 acres in area; and streams, sloughs, estuaries, and canals from 120 feet to one-eighth of a statute mile wide.

Wooded pasture.—Improved pasture with more than 16.7 percent stocking in live trees, but less than 25 percent stocking in growing-stock trees. Area is currently improved for grazing or there is other evidence of grazing.

Wooded strip.—An acre or more of natural continuous forest land that would otherwise meet survey standards for timberland except that it is less than 120 feet wide.

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Table 1. -- Area of land by Forest Survey Unit, county, and major land-use class, Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	Total[1] land area	Forest land				Other[2] land
		Total forest	Timberland	Reserved forest land	Other forest land	
Aspen-Birch Unit						
Carlton	552.8	352.6	340.5	6.9	5.2	200.2
Cook	903.8	854.9	565.4	286.6	2.9	48.9
Koochiching	1,989.1	1,732.8	1,423.9	21.2	287.7	256.3
Lake	1,313.7	1,199.1	850.1	329.8	19.2	114.6
St. Louis	3,919.9	3,223.7	2,698.8	359.9	165.0	696.2
Total	8,679.3	7,363.1	5,878.7	1,004.4	480.0	1,316.2
Northern Pine Unit						
Aitkin	1,173.6	754.2	700.5	1.0	52.7	419.4
Becker	839.7	335.3	332.3	3.0	-	504.4
Beltrami	1,604.5	928.5	835.6	2.9	90.0	676.0
Cass	1,301.2	868.6	841.6	1.6	25.4	432.6
Clearwater	639.7	318.0	285.2	18.7	14.1	321.7
Crow Wing	644.8	387.9	385.7	-	2.2	256.9
Hubbard	598.8	407.9	399.8	5.9	2.2	190.9
Itasca	1,703.4	1,361.4	1,323.4	0.8	37.2	342.0
Lake of the Woods	829.6	495.7	391.5	-	104.2	333.9
Mahnomen	357.8	114.8	112.1	1.6	1.1	243.0
Roseau	1,073.3	225.7	217.2	-	8.5	847.6
Wadena	344.1	119.1	119.1	-	-	225.0
Total	11,110.5	6,317.1	5,944.0	35.5	337.6	4,793.4
Central Hardwood Unit						
Anoka-Dakota-Ramsey-Washington	990.6	83.8	70.4	10.3	3.1	906.8
Benton-Sherburne	539.5	88.1	85.4	0.8	1.9	451.4
Carver-Hennepin-Scott	799.4	50.6	44.9	5.7	-	748.8
Chisago-Isanti	548.5	102.7	101.6	1.1	-	445.8
Douglas-Todd	1,014.2	128.5	128.1	0.4	-	885.7
Fillmore-Olmsted	970.7	142.3	139.3	3.0	-	828.4
Goodhue	488.3	68.8	68.8	-	-	419.5
Houston	361.0	135.7	133.9	-	1.8	225.3
Kanabec	337.5	139.8	139.8	-	-	197.7
Le Sueur-Rice	606.2	42.3	42.1	0.2	-	563.9
Mille Lacs	369.9	145.2	138.4	5.9	0.9	224.7
Morrison	719.2	167.4	166.4	1.0	-	551.8
Otter Tail	1,262.8	218.2	208.2	4.5	5.5	1,044.6
Pine	909.5	520.7	486.4	33.7	0.6	388.8
Stearns	856.4	69.2	69.2	-	-	787.2
Wabasha	343.6	67.9	67.9	-	-	275.7
Winona	403.3	129.1	126.6	2.5	-	274.2
Wright	430.1	44.1	43.3	0.8	-	386.0
Total	11,950.7	2,344.4	2,260.7	69.9	13.8	9,606.3

(Table 1 continued on next page)

(Table 1 continued)

Forest Survey Unit and county	Total[1] land area	Forest land				Other[2] land
		Total forest	Timberland	Reserved forest land	Other forest land	
Prairie Unit						
Blue Earth-Fairbault	936.8	46.5	46.5	-	-	890.3
Clay-Norman	1,232.3	48.4	48.4	-	-	1,183.9
Eastern Group[3]	1,733.7	46.0	45.4	0.6	-	1,687.7
Kandiyohi-Meeker	901.2	43.4	42.0	1.4	-	857.8
Kittson	706.6	72.1	65.1	2.8	4.2	634.5
Marshall	1,126.5	137.1	133.3	-	3.8	989.4
Northern Group[4]	1,604.3	50.4	49.0	1.4	-	1,553.9
Pennington-Red Lake	672.3	62.1	62.1	-	-	610.2
Polk	1,268.2	59.6	58.5	-	1.1	1,208.6
Southern Group[5]	2,541.8	36.4	36.4	-	-	2,505.4
Western Group[6]	6,446.7	54.5	53.1	1.4	-	6,392.2
Total	19,170.4	656.5	639.8	7.6	9.1	18,513.9
All counties	50,910.9	16,681.1	14,723.2	1,117.4	840.5	34,229.8

[1]From U.S. Bureau of the Census, 1980.

[2]Includes 337.5 thousand acres of water according to FIA standards of area classification, but defined by the Bureau of the Census as land.

[3]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[4]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[5]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[6]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 2. -- Area of timberland by Forest Survey Unit, county, and ownership class, Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	All ownerships	National forest	Bureau of Land Mgmt.	Other federal	State	County and municipal	Indian	Forest industry	Individual	Corporate
Aspen-Birch Unit										
Carlton	340.5	-	-	-	58.9	58.0	10.4	27.0	173.8	12.4
Cook	565.4	362.8	-	2.3	75.0	9.2	32.7	26.2	39.2	18.0
Koochiching	1,423.9	-	12.1	17.5	734.4	278.8	35.3	203.1	125.6	17.1
Lake	850.1	384.6	-	3.3	106.7	143.6	-	78.3	89.9	43.7
St. Louis	2,698.8	506.5	1.4	8.9	356.3	744.8	24.0	127.7	678.5	250.7
Total	5,878.7	1,253.9	13.5	32.0	1,331.3	1,234.4	102.4	462.3	1,107.0	341.9
Northern Pine Unit										
Aitkin	700.5	-	-	7.9	249.9	196.3	-	11.3	228.8	6.3
Becker	332.3	-	-	26.2	20.2	87.6	2.3	4.7	185.3	6.0
Beltrami	835.6	57.8	-	-	243.6	138.6	201.6	2.0	183.6	8.4
Cass	841.6	241.1	-	3.0	104.7	232.9	18.4	32.4	193.8	15.3
Clearwater	285.2	-	-	2.6	25.3	66.8	54.8	2.9	130.1	2.7
Crow Wing	385.7	-	-	-	20.4	89.6	-	16.5	231.5	27.7
Hubbard	399.8	-	-	0.9	52.1	121.2	-	21.5	196.1	8.0
Itasca	1,323.4	268.3	-	-	253.8	255.7	2.3	169.0	303.0	71.3
Lake of the Woods	391.5	-	12.6	7.9	226.0	3.1	72.9	2.2	63.7	3.1
Mahnomen	112.1	-	-	11.3	23.6	5.7	16.6	-	54.9	-
Roseau	217.2	-	-	10.7	123.9	3.4	4.9	-	71.1	3.2
Wadena	119.1	-	-	-	13.4	0.8	-	22.5	79.1	3.3
Total	5,944.0	567.2	12.6	70.5	1,356.9	1,201.7	373.8	285.0	1,921.0	155.3
Central Hardwood Unit										
Anoka-Dakota-Ramsey-Washington	70.4	-	-	-	6.6	1.0	-	-	54.2	8.6
Benton-Sherburne	85.4	-	-	18.2	8.6	-	-	-	57.3	1.3
Carver-Hennepin-Scott	44.9	-	-	2.1	6.2	3.9	-	-	30.6	2.1
Chisago-Isanti	101.6	-	-	-	7.5	3.7	-	-	86.7	3.7
Douglas-Todd	128.1	-	-	6.9	6.1	1.6	-	-	110.4	3.1
Fillmore-Olmsted	139.3	-	-	-	13.0	1.8	-	1.4	120.1	3.0
Goodhue	68.8	-	-	3.1	6.2	-	-	-	55.5	3.2
Houston	133.9	-	-	6.6	8.8	-	1.2	-	115.1	2.2
Kanabec	139.8	-	-	-	14.9	7.8	-	-	115.8	1.3
Le Sueur-Rice	42.1	-	-	-	3.2	0.9	-	-	38.0	-
Mille Lacs	138.4	-	-	4.8	33.8	-	5.0	-	94.3	0.5
Morrison	166.4	-	-	0.7	30.4	-	-	-	116.3	19.0
Otter Tail	208.2	-	-	-	3.3	1.2	-	-	196.2	7.5
Pine	486.4	-	-	3.1	111.5	32.3	1.4	2.6	310.7	24.8
Stearns	69.2	-	-	-	-	0.9	-	-	65.1	3.2
Wabasha	67.9	-	-	6.5	10.1	-	-	-	47.8	3.5
Winona	126.6	-	-	3.3	25.2	2.0	-	-	90.5	5.6
Wright	43.3	-	-	-	2.8	1.7	-	-	36.5	2.3
Total	2,260.7	-	-	55.3	298.2	59.6	7.6	4.0	1,741.1	94.9

(Table 2 continued on next page)

(Table 2 continued)

Forest Survey Unit and county	All ownerships	National forest	Bureau of Land Mgmt.	Other federal	State	County and municipal	Indian	Forest industry	Individual	Corporate
Prairie Unit										
Blue Earth-Fairbault	46.5	-	-	-	-	-	-	-	45.3	1.2
Clay-Norman	48.4	-	-	-	1.1	2.4	-	-	42.1	2.8
Eastern Group[1]	45.4	-	-	-	2.8	-	-	-	40.5	2.1
Kandiyohi-Meeker	42.0	-	-	3.1	4.3	-	-	-	33.7	0.9
Kittson	65.1	-	-	-	18.4	2.3	-	-	42.0	2.4
Marshall	133.3	-	-	8.6	37.4	-	-	-	86.4	0.9
Northern Group[2]	49.0	-	-	-	3.3	-	-	-	43.4	2.3
Pennington-Red Lake	62.1	-	-	0.9	2.2	-	-	-	57.9	1.1
Polk	58.5	-	-	-	5.6	2.3	-	-	47.3	3.3
Southern Group[3]	36.4	-	-	-	-	-	-	-	36.4	-
Western Group[4]	53.1	-	-	1.2	1.0	-	-	-	47.0	3.9
Total	639.8	-	-	13.8	76.1	7.0	-	-	522.0	20.9
All counties	14,723.2	1,821.1	26.1	171.6	3,062.5	2,502.7	483.8	751.3	5,291.1	613.0

[1]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[2]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[3]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[4]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 3. -- Area of timberland by Forest Survey Unit, county, and forest type group/local type, Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	All types	Forest type group/local type																	
		White-red-jack pine				Spruce-fir						Oak-hickory	Elm-ash-cottonwood	Maple-beech-birch	Aspen-birch				Non-stocked
		Total	Jack pine	Red pine	White pine	Total	Balsam fir	White spruce	Black spruce	Northern white-cedar	Tamarack	Oak-hickory	Elm-ash-soft maple	Maple-basswood	Total	Aspen	Paper birch	Balsam poplar	Non-stocked
Aspen-Birch Unit																			
Carlton	340.5	8.9	-	8.3	0.6	68.6	14.3	2.3	22.1	4.8	25.1	3.2	43.0	29.5	179.5	142.7	21.7	15.1	7.8
Cook	565.4	23.3	9.1	10.6	3.6	230.7	92.9	18.1	62.6	53.6	3.5	-	14.1	41.5	253.2	181.5	67.5	4.2	2.6
Koochiching	1,423.9	38.1	17.4	19.0	1.7	757.1	90.5	9.2	332.6	226.0	98.8	1.3	129.3	19.9	465.7	373.3	24.8	67.6	12.5
Lake	850.1	70.1	28.3	33.1	8.7	329.8	123.1	18.5	133.1	51.3	3.8	1.5	33.4	59.6	352.0	187.4	152.0	12.6	3.7
St. Louis	2,698.8	171.7	88.3	64.7	18.7	871.8	223.5	22.0	392.8	109.4	124.1	3.3	168.0	110.9	1,335.3	1,092.2	186.0	57.1	37.8
Total	5,878.7	312.1	143.1	135.7	33.3	2,258.0	544.3	70.1	943.2	445.1	255.3	9.3	387.8	261.4	2,585.7	1,977.1	452.0	156.6	64.4
Northern Pine Unit																			
Aitkin	700.5	9.6	1.3	8.3	-	173.1	13.8	2.7	56.7	18.8	81.1	24.4	92.9	127.8	267.8	221.3	37.5	9.0	4.9
Becker	332.3	18.6	10.8	6.6	1.2	32.2	9.4	-	3.0	-	19.8	46.7	20.6	49.8	162.2	144.8	16.7	0.7	2.2
Beltrami	835.6	61.4	30.2	30.0	1.2	212.5	17.3	3.7	48.1	59.7	83.7	16.2	71.7	56.9	408.9	308.1	34.7	66.1	8.0
Cass	841.6	108.6	48.0	54.6	6.0	115.5	17.5	5.0	16.5	40.9	35.6	50.2	49.3	68.0	444.8	358.8	71.2	14.8	5.2
Clearwater	285.2	13.4	5.6	6.9	0.9	36.3	11.4	-	6.5	7.8	10.6	7.3	19.4	31.1	177.7	143.8	14.3	19.6	-
Crow Wing	385.7	46.4	32.8	11.3	2.3	26.8	0.8	0.9	9.2	0.9	15.0	77.9	38.1	23.6	171.1	147.4	23.7	-	1.8
Hubbard	399.8	85.0	59.4	23.3	2.3	34.3	14.1	3.1	5.2	0.9	11.0	14.1	21.9	15.1	227.1	199.1	24.7	3.3	2.3
Itasca	1,323.4	88.7	32.4	49.4	6.9	351.0	75.8	18.4	119.9	68.5	68.4	12.1	128.3	84.6	651.8	522.0	82.1	47.7	6.9
Lake of the Woods	391.5	27.8	23.1	4.7	-	174.3	14.3	3.3	69.3	33.6	53.8	1.8	11.5	-	163.7	123.9	10.1	29.7	12.4
Mahnomen	112.1	-	-	-	-	3.0	0.9	1.1	-	-	1.0	17.6	7.7	33.9	49.9	45.0	3.1	1.8	-
Roseau	217.2	25.9	22.3	3.6	-	45.5	4.0	1.8	13.8	5.4	20.5	1.0	19.7	-	122.9	90.4	-	32.5	2.2
Wadena	119.1	48.3	29.5	15.3	3.5	4.2	0.9	-	-	-	3.3	22.1	6.9	1.4	36.2	33.6	1.3	1.3	-
Total	5,944.0	533.7	295.4	214.0	24.3	1,208.7	180.2	40.0	348.2	236.5	403.8	291.4	488.0	492.2	2,884.1	2,338.2	319.4	226.5	45.9
Central Hardwood Unit																			
Anoka-Dakota-Ramsey-Washington	70.4	0.6	0.6	-	-	-	-	-	-	-	-	30.8	7.9	22.4	8.7	5.8	2.9	-	-
Benton-Sherburne	85.4	11.4	3.6	7.8	-	-	-	-	-	-	-	51.7	10.3	6.6	5.4	5.4	-	-	-
Carver-Hennepin-Scott	44.9	-	-	-	-	-	-	-	-	-	-	21.3	12.5	10.5	0.6	0.6	-	-	-
Chisago-Isanti	101.6	3.6	0.4	3.2	-	5.4	-	0.2	2.4	-	2.8	39.7	20.0	19.5	13.4	11.2	2.2	-	-
Douglas-Todd	128.1	1.1	1.1	-	-	3.8	-	-	-	-	3.8	47.1	28.3	21.3	26.5	23.3	2.0	1.2	-
Fillmore-Olmsted	139.3	-	-	-	-	-	-	-	-	-	-	83.8	17.8	35.0	2.7	2.7	-	-	-
Goodhue	68.8	-	-	-	-	-	-	-	-	-	-	24.5	14.5	16.3	13.5	8.9	4.6	-	-
Houston	133.9	0.5	-	0.5	-	-	-	-	-	-	-	92.7	11.4	16.8	12.5	6.2	6.3	-	-
Kanabec	139.8	-	-	-	-	4.6	-	0.8	2.2	-	1.6	27.5	16.3	31.4	58.6	53.4	4.1	1.1	1.4
Le Sueur-Rice	42.1	-	-	-	-	-	-	-	-	-	-	4.4	11.7	25.2	0.8	0.8	-	-	-
Mille Lacs	138.4	-	-	-	-	4.8	-	-	-	-	4.8	21.5	25.6	35.3	51.2	44.8	6.4	-	-
Morrison	166.4	8.2	2.0	3.8	2.4	4.0	-	-	-	-	4.0	50.8	9.4	22.4	71.6	67.6	4.0	-	-
Otter Tail	208.2	3.0	2.8	-	0.2	8.2	-	-	-	-	8.2	51.0	23.8	62.7	58.3	48.8	4.1	5.4	1.2
Pine	486.4	19.7	8.3	8.9	2.5	46.5	8.3	-	24.1	-	14.1	28.3	52.3	74.0	264.4	242.6	18.2	3.6	1.2
Stearns	69.2	-	-	-	-	1.5	-	-	-	-	1.5	21.5	19.2	23.0	2.4	-	-	2.4	1.6
Wabasha	67.9	0.3	-	0.3	-	-	-	-	-	-	-	48.3	3.9	11.7	3.7	3.7	-	-	-
Winona	126.6	-	-	-	-	-	-	-	-	-	-	91.3	15.4	17.9	2.0	1.0	1.0	-	-
Wright	43.3	-	-	-	-	-	-	-	-	-	-	5.9	10.8	25.6	1.0	1.0	-	-	-
Total	2,260.7	48.4	18.8	24.5	5.1	78.8	8.3	1.0	28.7	-	40.8	742.1	311.1	477.6	597.3	527.8	55.8	13.7	5.4

(Table 3 continued on next page)

(Table 3 continued)

Forest Survey Unit and county	All types	Forest type group/local type																	
		White-red-jack pine				Spruce-fir						Oak-hickory	Elm-ash-cottonwood	Maple-beech-birch	Aspen-birch				Non-stocked
		Total	Jack pine	Red pine	White pine	Total	Balsam fir	White spruce	Black spruce	Northern white-cedar	Tamarack	Oak-hickory	Elm-ash-soft maple	Maple-basswood	Total	Aspen	Paper birch	Balsam poplar	Non-stocked
Prairie Unit																			
Blue Earth-Fairbault	46.5	-	-	-	-	-	-	-	-	-	-	10.8	12.2	23.5	-	-	-	-	-
Clay-Norman	48.4	-	-	-	-	-	-	-	-	-	-	16.5	10.1	5.4	16.4	16.4	-	-	-
Eastern Group[1]	45.4	-	-	-	-	-	-	-	-	-	-	25.9	8.2	10.4	0.9	0.9	-	-	-
Kandiyohi-Meeker	42.0	-	-	-	-	-	-	-	-	-	-	13.8	10.0	18.2	-	-	-	-	-
Kittson	65.1	-	-	-	-	-	-	-	-	-	-	2.2	3.6	8.0	51.3	50.2	-	1.1	-
Marshall	133.3	-	-	-	-	7.2	-	-	2.0	-	5.2	6.6	7.7	4.3	106.4	87.3	-	19.1	1.1
Northern Group[2]	49.0	-	-	-	-	-	-	-	-	-	-	7.7	13.7	26.4	1.2	1.2	-	-	-
Pennington-Red Lake	62.1	-	-	-	-	-	-	-	-	-	-	13.4	-	6.8	41.9	35.3	-	6.6	-
Polk	58.5	1.1	-	1.1	-	-	-	-	-	-	-	12.1	9.0	14.6	21.7	20.6	-	1.1	-
Southern Group[3]	36.4	-	-	-	-	-	-	-	-	-	-	7.4	8.4	20.6	-	-	-	-	-
Western Group[4]	53.1	1.0	-	-	1.0	-	-	-	-	-	-	6.4	20.1	23.7	-	-	-	-	1.9
Total	639.8	2.1	-	1.1	1.0	7.2	-	-	2.0	-	5.2	122.8	103.0	161.9	239.8	211.9	-	27.9	3.0
All counties	14,723.2	896.3	457.3	375.3	63.7	3,552.7	732.8	111.1	1,322.1	681.6	705.1	1,165.6	1,289.9	1,393.1	6,306.9	5,055.0	827.2	424.7	118.7

[1]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[2]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[3]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[4]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 4. -- Area of timberland by Forest Survey Unit, county, and stand-size class, Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	All stands	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Nonstocked
Aspen-Birch Unit					
Carlton	340.5	72.8	139.8	120.1	7.8
Cook	565.4	207.1	215.0	140.7	2.6
Koochiching	1,423.9	273.5	524.9	613.0	12.5
Lake	850.1	240.7	317.1	288.6	3.7
St. Louis	2,698.8	708.2	972.7	980.1	37.8
Total	5,878.7	1,502.3	2,169.5	2,142.5	64.4
Northern Pine Unit					
Aitkin	700.5	235.2	274.6	185.8	4.9
Becker	332.3	141.8	137.0	51.3	2.2
Beltrami	835.6	253.4	321.5	252.7	8.0
Cass	841.6	319.2	317.0	200.2	5.2
Clearwater	285.2	96.5	113.2	75.5	-
Crow Wing	385.7	159.2	146.2	78.5	1.8
Hubbard	399.8	104.0	199.6	93.9	2.3
Itasca	1,323.4	427.4	432.6	456.5	6.9
Lake of the Woods	391.5	90.6	142.7	145.8	12.4
Mahnomen	112.1	30.5	54.3	27.3	-
Roseau	217.2	49.9	76.9	88.2	2.2
Wadena	119.1	34.4	43.6	41.1	-
Total	5,944.0	1,942.1	2,259.2	1,696.8	45.9
Central Hardwood Unit					
Anoka-Dakota-Ramsey-Washington	70.4	47.6	19.6	3.2	-
Benton-Sherburne	85.4	44.8	25.2	15.4	-
Carver-Hennepin-Scott	44.9	28.5	6.0	10.4	-
Chisago-Isanti	101.6	46.4	28.9	26.3	-
Douglas-Todd	128.1	68.2	36.3	23.6	-
Fillmore-Olmsted	139.3	104.4	20.8	14.1	-
Goodhue	68.8	54.6	10.0	4.2	-
Houston	133.9	98.1	14.3	21.5	-
Kanabec	139.8	49.3	49.0	40.1	1.4
Le Sueur-Rice	42.1	28.9	3.5	9.7	-
Mille Lacs	138.4	51.1	59.7	27.6	-
Morrison	166.4	63.0	85.2	18.2	-
Otter Tail	208.2	96.3	67.0	43.7	1.2
Pine	486.4	131.4	210.3	143.5	1.2
Stearns	69.2	39.9	18.1	9.6	1.6
Wabasha	67.9	51.0	12.4	4.5	-
Winona	126.6	96.7	22.0	7.9	-
Wright	43.3	33.1	3.5	6.7	-
Total	2,260.7	1,133.3	691.8	430.2	5.4

(Table 4 continued on next page)

(Table 4 continued)

Forest Survey Unit and county	All stands	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Nonstocked
Prairie Unit					
Blue Earth-Fairbault	46.5	37.7	2.4	6.4	-
Clay-Norman	48.4	30.9	8.8	8.7	-
Eastern Group[1]	45.4	36.1	4.4	4.9	-
Kandiyohi-Meeker	42.0	35.4	1.9	4.7	-
Kittson	65.1	6.0	31.8	27.3	-
Marshall	133.3	15.3	46.1	70.8	1.1
Northern Group[2]	49.0	38.4	2.3	8.3	-
Pennington-Red Lake	62.1	18.9	19.9	23.3	-
Polk	58.5	31.2	19.8	7.5	-
Southern Group[3]	36.4	25.2	4.8	6.4	-
Western Group[4]	53.1	37.5	7.3	6.4	1.9
Total	639.8	312.6	149.5	174.7	3.0
All counties	14,723.2	4,890.3	5,270.0	4,444.2	118.7

[1]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.
[2]Includes: McLeod, Nicollet, Renville, and Sibley counties.
[3]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.
[4]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 5. -- Area of timberland by Forest Survey Unit, county, and potential productivity class, Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	All classes	Potential productivity class (cubic feet of growth per acre per year)				
		165+	120-164	85-119	50-84	20-49
Aspen-Birch Unit						
Carlton	340.5	-	5.3	68.0	132.9	134.3
Cook	565.4	-	3.8	82.8	186.1	292.7
Koochiching	1,423.9	-	16.1	222.7	324.7	860.4
Lake	850.1	-	11.5	99.7	254.3	484.6
St. Louis	2,698.8	0.9	55.8	496.4	935.6	1,210.1
Total	5,878.7	0.9	92.5	969.6	1,833.6	2,982.1
Northern Pine Unit						
Aitkin	700.5	-	10.1	145.9	228.0	316.5
Becker	332.3	-	1.7	62.2	149.0	119.4
Beltrami	835.6	-	17.3	145.5	280.4	392.4
Cass	841.6	1.5	21.8	204.8	359.4	254.1
Clearwater	285.2	-	6.5	85.2	111.9	81.6
Crow Wing	385.7	-	-	40.4	203.2	142.1
Hubbard	399.8	-	7.7	99.4	176.1	116.6
Itasca	1,323.4	1.6	62.1	457.5	420.3	381.9
Lake of the Woods	391.5	-	-	50.4	119.9	221.2
Mahnomen	112.1	-	-	21.7	45.9	44.5
Roseau	217.2	-	1.8	18.3	83.9	113.2
Wadena	119.1	-	3.9	22.7	53.3	39.2
Total	5,944.0	3.1	132.9	1,354.0	2,231.3	2,222.7
Central Hardwood Unit						
Anoka-Dakota-Ramsey-Washington	70.4	-	-	14.8	47.7	7.9
Benton-Sherburne	85.4	-	3.1	7.1	34.0	41.2
Carver-Hennepin-Scott	44.9	-	-	10.1	19.3	15.5
Chisago-Isanti	101.6	-	2.4	15.2	43.4	40.6
Douglas-Todd	128.1	-	-	24.7	53.1	50.3
Fillmore-Olmsted	139.3	1.4	1.1	24.5	57.8	54.5
Goodhue	68.8	-	0.9	23.5	28.9	15.5
Houston	133.9	1.1	3.1	35.8	54.5	39.4
Kanabec	139.8	1.0	1.2	45.6	65.3	26.7
Le Sueur-Rice	42.1	-	-	20.3	10.3	11.5
Mille Lacs	138.4	-	-	22.2	79.2	37.0
Morrison	166.4	-	1.3	39.1	80.2	45.8
Otter Tail	208.2	-	-	31.8	84.4	92.0
Pine	486.4	-	5.8	144.2	205.3	131.1
Stearns	69.2	-	-	5.2	31.0	33.0
Wabasha	67.9	0.3	2.3	18.7	29.2	17.4
Winona	126.6	-	3.2	25.4	49.3	48.7
Wright	43.3	-	-	9.4	26.7	7.2
Total	2,260.7	3.8	24.4	517.6	999.6	715.3

(Table 5 continued on next page)

(Table 5 continued)

Forest Survey Unit and county	All classes	Potential productivity class (cubic feet of growth per acre per year)				
		165+	120-164	85-119	50-84	20-49
Prairie Unit						
Blue Earth-Fairbault	46.5	2.0	-	11.9	14.7	17.9
Clay-Norman	48.4	-	-	3.6	26.5	18.3
Eastern Group[1]	45.4	1.9	-	2.8	14.8	25.9
Kandiyohi-Meeker	42.0	-	-	10.9	20.3	10.8
Kittson	65.1	-	-	10.3	30.3	24.5
Marshall	133.3	-	-	18.3	71.8	43.2
Northern Group[2]	49.0	-	3.1	13.4	19.5	13.0
Pennington-Red Lake	62.1	-	-	9.2	33.8	19.1
Polk	58.5	-	-	9.7	23.2	25.6
Southern Group[3]	36.4	-	1.2	9.3	12.8	13.1
Western Group[4]	53.1	-	-	7.4	23.0	22.7
Total	639.8	3.9	4.3	106.8	290.7	234.1
All counties	14,723.2	11.7	254.1	2,948.0	5,355.2	6,154.2

[1]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.
[2]Includes: McLeod, Nicollet, Renville, and Sibley counties.
[3]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.
[4]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 6. -- Area of timberland by Forest Survey Unit, county, and stocking class of growing-stock trees[1], Minnesota, 1990

(In thousand acres)

Forest Survey Unit and county	All classes	Stocking class of growing-stock trees				
		Nonstocked[2]	Poorly stocked	Moderately stocked	Fully stocked	Over-stocked
Aspen-Birch Unit						
Carlton	340.5	10.5	81.6	97.8	104.2	46.4
Cook	565.4	4.0	63.8	168.0	228.5	101.1
Koochiching	1,423.9	14.0	210.3	400.6	419.9	379.1
Lake	850.1	7.8	127.1	311.1	283.1	121.0
St. Louis	2,698.8	58.0	462.3	962.0	789.1	427.4
Total	5,878.7	94.3	945.1	1,939.5	1,824.8	1,075.0
Northern Pine Unit						
Aitkin	700.5	8.5	167.7	265.1	176.5	82.7
Becker	332.3	2.2	71.0	158.3	84.9	15.9
Beltrami	835.6	10.9	168.3	305.9	238.1	112.4
Cass	841.6	5.2	119.8	300.7	298.4	117.5
Clearwater	285.2	0.9	67.8	105.3	81.7	29.5
Crow Wing	385.7	2.9	76.4	177.0	93.5	35.9
Hubbard	399.8	2.3	72.4	174.6	108.6	41.9
Itasca	1,323.4	15.2	193.8	492.7	388.5	233.2
Lake of the Woods	391.5	20.1	90.9	124.9	106.0	49.6
Mahnomen	112.1	-	18.8	50.0	28.6	14.7
Roseau	217.2	3.6	62.3	70.7	59.7	20.9
Wadena	119.1	-	34.1	63.7	16.9	4.4
Total	5,944.0	71.8	1,143.3	2,288.9	1,681.4	758.6
Central Hardwood Unit						
Anoka-Dakota-Ramsey-Washington	70.4	-	24.7	39.2	6.5	-
Benton-Sherburne	85.4	3.7	37.0	36.0	5.5	3.2
Carver-Hennepin-Scott	44.9	1.7	15.0	18.7	8.5	1.0
Chisago-Isanti	101.6	-	51.9	35.4	11.9	2.4
Douglas-Todd	128.1	2.5	34.0	71.4	19.7	0.5
Fillmore-Olmsted	139.3	5.5	46.5	64.1	23.2	-
Goodhue	68.8	0.8	19.8	34.0	13.1	1.1
Houston	133.9	-	32.0	73.1	26.4	2.4
Kanabec	139.8	2.5	39.4	71.0	19.4	7.5
Le Sueur-Rice	42.1	-	7.9	30.7	3.5	-
Mille Lacs	138.4	3.2	37.8	58.2	30.3	8.9
Morrison	166.4	-	42.1	91.9	25.7	6.7
Otter Tail	208.2	5.7	82.6	92.1	23.0	4.8
Pine	486.4	2.4	141.7	207.0	105.4	29.9
Stearns	69.2	6.2	27.1	31.1	4.8	-
Wabasha	67.9	-	18.7	44.1	5.1	-
Winona	126.6	1.0	32.2	72.3	20.0	1.1
Wright	43.3	2.0	16.1	21.8	3.4	-
Total	2,260.7	37.2	706.5	1,092.1	355.4	69.5

(Table 6 continued on next page)

(Table 6 continued)

Forest Survey Unit and county	All classes	Stocking class of growing-stock trees				
		Nonstocked[2]	Poorly stocked	Moderately stocked	Fully stocked	Over-stocked
Prairie Unit						
Blue Earth-Fairbault	46.5	2.0	12.3	27.4	4.8	-
Clay-Norman	48.4	0.9	13.2	21.7	9.0	3.6
Eastern Group[3]	45.4	1.9	21.4	18.3	3.8	-
Kandiyohi-Meeker	42.0	1.5	10.6	29.9	-	-
Kittson	65.1	3.4	16.5	17.0	15.9	12.3
Marshall	133.3	2.2	34.1	44.1	34.4	18.5
Northern Group[4]	49.0	-	8.2	25.9	13.8	1.1
Pennington-Red Lake	62.1	-	17.5	30.4	10.9	3.3
Polk	58.5	2.2	18.8	29.7	6.7	1.1
Southern Group[5]	36.4	-	10.5	21.5	1.5	2.9
Western Group[6]	53.1	3.0	24.2	21.7	2.7	1.5
Total	639.8	17.1	187.3	287.6	103.5	44.3
All counties	14,723.2	220.4	2,982.2	5,608.1	3,965.1	1,947.4

[1]This table is based on the stocking percent of growing-stock trees, rather than that of all live trees. For this table, to use the definition of stocking found in the Appendix, replace the term "all live" with "growing-stock."

[2]Area of nonstocked in this table and Table 8 differs from that in other tables in this report because this table includes land stocked with only growing-stock trees, rather than with all alive trees.

[3]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[4]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[5]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[6]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 7. -- Area of timberland by forest type group/local type and ownership class, Minnesota, 1990

(In thousand acres)

Forest type group/ local type	All ownerships	Ownership class										
		Total public	Public					Total private	Private			
			National forest	Bureau of Land Mgmt.	Other federal	State	County and municipal		Indian	Forest industry	Individual	Corporate
White-red-jack pine												
Jack pine	457.3	253.7	78.1	2.0	5.0	95.8	72.8	203.6	5.8	51.9	133.4	12.5
Red pine	375.3	253.6	117.8	0.9	4.9	68.2	61.8	121.7	12.6	42.1	60.9	6.1
White pine	63.7	26.6	15.3	-	0.9	5.7	4.7	37.1	1.9	6.0	24.1	5.1
Total	896.3	533.9	211.2	2.9	10.8	169.7	139.3	362.4	20.3	100.0	218.4	23.7
Spruce-fir												
Balsam fir	732.8	495.2	189.0	-	1.3	150.7	154.2	237.6	12.9	69.7	119.4	35.6
White spruce	111.1	76.0	30.5	1.0	-	23.8	20.7	35.1	2.8	13.5	17.0	1.8
Black spruce	1,322.1	1,036.2	248.8	10.3	9.2	561.9	206.0	285.9	41.9	62.7	143.4	37.9
Northern white-cedar	681.6	503.3	93.1	2.4	7.8	288.1	111.9	178.3	60.6	47.2	55.9	14.6
Tamarack	705.1	483.2	32.3	1.0	4.9	321.7	123.3	221.9	43.8	9.1	151.0	18.0
Total	3,552.7	2,593.9	593.7	14.7	23.2	1,346.2	616.1	958.8	162.0	202.2	486.7	107.9
Oak-hickory												
Oak-hickory	1,165.6	206.1	10.0	-	41.8	101.6	52.7	959.5	8.1	2.8	904.8	43.8
Elm-ash-cottonwood												
Elm-ash-soft maple	1,289.9	491.9	59.1	1.6	19.1	198.0	214.1	798.0	40.1	65.5	640.7	51.7
Maple-beech-birch												
Maple-basswood	1,393.1	447.8	109.7	-	24.1	128.1	185.9	945.3	41.5	49.6	793.8	60.4
Aspen-birch												
Aspen	5,055.0	2,555.2	641.7	5.8	36.3	865.5	1,005.9	2,499.8	160.6	273.1	1,822.3	243.8
Paper birch	827.2	472.6	165.8	-	8.2	106.3	192.3	354.6	31.7	33.8	233.9	55.2
Balsam poplar	424.7	205.3	21.1	-	5.2	105.9	73.1	219.4	15.9	20.9	161.0	21.6
Total	6,306.9	3,233.1	828.6	5.8	49.7	1,077.7	1,271.3	3,073.8	208.2	327.8	2,217.2	320.6
Nonstocked	118.7	77.3	8.8	1.1	2.9	41.2	23.3	41.4	3.6	3.4	29.5	4.9
All types	14,723.2	7,584.0	1,821.1	26.1	171.6	3,062.5	2,502.7	7,139.2	483.8	751.3	5,291.1	613.0

Table 8. -- Area of timberland by ownership class and stocking class of growing-stock trees[1], Minnesota, 1990

(In thousand acres)

Ownership class	All classes	Stocking class of growing-stock trees				
		Nonstocked [2]	Poorly stocked	Moderately stocked	Fully stocked	Over-stocked
Public						
National forest	1,821.1	16.2	137.5	542.3	739.4	385.7
Bureau of Land Mgmt.	26.1	1.1	5.8	5.5	8.7	5.0
Other federal	171.6	2.9	44.6	77.7	31.6	14.8
State	3,062.5	60.8	569.2	1,007.4	872.0	553.1
County and municipal	2,502.7	39.9	485.1	919.5	684.7	373.5
Total	7,584.0	120.9	1,242.2	2,552.4	2,336.4	1,332.1
Private						
Indian	483.8	5.0	105.2	174.7	122.4	76.5
Forest industry	751.3	5.6	111.7	257.7	232.7	143.6
Individual	5,291.1	82.4	1,409.0	2,363.7	1,113.1	322.9
Corporate	613.0	6.5	114.1	259.6	160.5	72.3
Total	7,139.2	99.5	1,740.0	3,055.7	1,628.7	615.3
All owners	14,723.2	220.4	2,982.2	5,608.1	3,965.1	1,947.4

[1]This table is based on the stocking percent of growing-stock trees, rather than that of all live trees. For this table, to use the definition of stocking found in the Appendix, replace the term "all live" with "growing-stock."

[2]Area of nonstocked in this table and in Table 6 differs from that in other tables in this report because this table includes land stocked with only growing-stock trees, rather than with all live trees.

Table 9. -- Area of timberland by forest type group/local type and stand-size class, Minnesota, 1990

(In thousand acres)

Forest type group/ local type	All stands	Stand-size class			
		Sawtimber	Poletimber	Sapling-seedling	Nonstocked
White-red-jack pine					
Jack pine	457.3	206.4	152.5	98.4	-
Red pine	375.3	174.1	85.7	115.5	-
White pine	63.7	52.8	8.5	2.4	-
Total	896.3	433.3	246.7	216.3	-
Spruce-fir					
Balsam fir	732.8	181.5	315.9	235.4	-
White spruce	111.1	31.9	34.9	44.3	-
Black spruce	1,322.1	69.0	448.4	804.7	-
Northern white-cedar	681.6	298.7	277.9	105.0	-
Tamarack	705.1	102.9	252.3	349.9	-
Total	3,552.7	684.0	1,329.4	1,539.3	-
Oak-hickory					
Oak-hickory	1,165.6	780.8	299.4	85.4	-
Elm-ash-cottonwood					
Elm-ash-soft maple	1,289.9	404.2	505.5	380.2	-
Maple-beech-birch					
Maple-basswood	1,393.1	763.6	386.0	243.5	-
Aspen-birch					
Aspen	5,055.0	1,513.7	1,840.1	1,701.2	-
Paper birch	827.2	198.9	505.8	122.5	-
Balsam poplar	424.7	111.8	157.1	155.8	-
Total	6,306.9	1,824.4	2,503.0	1,979.5	-
Nonstocked	118.7	-	-	-	118.7
All types	14,723.2	4,890.3	5,270.0	4,444.2	118.7

Table 10. -- Number of all live trees on timberland by species group and diameter class, Minnesota, 1990

(In thousand trees)

Species group	All classes	Diameter class (inches at breast height)											
		1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods													
Jack pine	164,327	45,333	33,320	33,600	25,947	15,616	6,718	2,696	779	237	55	26	-
Red pine	97,831	20,352	20,952	21,187	14,741	8,000	4,676	3,144	2,086	1,352	767	573	1
White pine	29,585	9,066	5,273	4,629	2,904	2,206	1,615	1,200	753	579	494	747	119
White spruce	78,622	28,790	18,129	13,231	7,860	4,470	2,906	1,460	870	501	254	151	-
Black spruce	1,039,448	514,723	328,948	143,887	40,720	9,028	1,720	262	114	22	11	12	1
Balsam fir	979,674	532,426	245,269	119,462	52,158	20,833	7,160	1,743	476	95	30	21	1
Tamarack	361,404	159,376	101,543	61,864	25,389	8,964	2,906	939	319	51	38	15	-
Eastern redcedar	14,057	7,230	3,404	1,690	1,270	260	144	31	13	12	-	3	-
Northern white-cedar	386,827	131,365	90,485	73,725	47,048	24,361	11,002	5,235	2,187	793	391	232	3
Other softwoods	2,036	351	659	543	301	107	38	28	8	-	-	1	-
Total softwoods	3,153,811	1,449,012	847,982	473,818	218,338	93,845	38,885	16,738	7,605	3,642	2,040	1,781	125
Hardwoods													
Select white oak	200,922	70,346	42,281	33,445	19,125	13,324	8,818	5,368	3,442	2,173	1,064	1,356	180
Select red oak	111,795	26,736	12,034	14,400	16,900	15,851	10,193	6,331	4,135	2,322	1,307	1,438	148
Other red oak	6,688	1,464	801	1,100	1,300	419	530	342	278	118	133	184	19
Select hickory	9,152	4,833	2,282	624	560	332	260	154	62	27	12	6	-
Other hickory	8,048	4,592	1,298	1,079	651	241	100	55	12	11	6	3	-
Basswood	192,117	78,585	36,178	27,623	18,630	13,604	7,584	4,488	2,424	1,451	703	783	64
Yellow birch	11,748	5,998	2,160	1,065	824	486	344	379	164	125	92	101	10
Hard maple	283,944	150,228	59,083	39,537	16,319	7,878	4,684	2,709	1,728	907	446	409	16
Soft maple	300,337	135,233	82,996	50,646	17,850	7,552	2,750	1,420	746	417	285	343	99
Elm	174,962	91,001	41,007	21,079	9,768	5,226	3,146	1,439	991	517	349	380	59
Black ash	527,551	277,683	124,118	64,093	34,549	15,831	6,848	2,825	989	393	131	86	5
White & green ash	88,731	47,913	16,064	8,943	5,975	4,318	2,515	1,411	751	385	221	207	28
Cottonwood	2,734	663	376	218	275	296	201	116	122	86	94	178	109
Willow	5,651	2,190	264	574	651	642	486	328	187	159	60	89	21
Hackberry	14,715	10,414	2,402	1,061	365	193	93	85	42	32	10	16	2
Balsam poplar	265,832	137,527	47,191	31,213	22,660	14,516	7,180	3,292	1,345	599	197	109	3
Bigtooth aspen	73,000	38,160	7,852	6,112	6,339	6,091	4,543	2,326	980	399	139	58	1
Quaking aspen	1,986,691	1,213,407	293,738	160,361	122,072	92,211	56,894	28,490	12,526	4,486	1,511	982	13
Paper birch	570,922	186,324	140,402	111,967	74,208	36,524	13,923	4,942	1,669	646	180	132	5
Black cherry	35,436	27,358	3,977	1,837	1,328	513	226	121	49	19	7	1	-
Black walnut	2,286	729	437	96	448	160	136	105	93	50	19	13	-
Butternut	2,946	736	616	202	518	295	235	126	106	73	17	19	3
Other hardwoods	68,351	34,857	13,179	8,311	5,107	3,141	1,609	1,005	496	285	179	155	27
Total hardwoods	4,944,559	2,546,977	930,736	585,586	376,422	239,644	133,298	67,857	33,337	15,680	7,162	7,048	812
Noncommercial species	343,481	288,665	41,776	10,867	1,695	359	79	28	-	5	-	5	2
All species	8,441,851	4,284,654	1,820,494	1,070,271	596,455	333,848	172,262	84,623	40,942	19,327	9,202	8,834	939

Table 11. -- Number of growing-stock trees on timberland by species group and diameter class, Minnesota, 1990

(In thousand trees)

Species group	All classes	Diameter class (inches at breast height)											
		1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods													
Jack pine	156,774	43,834	30,947	31,879	25,094	15,013	6,434	2,590	708	203	47	25	-
Red pine	96,400	20,083	20,382	21,059	14,572	7,855	4,583	3,121	2,068	1,352	763	561	1
White pine	25,930	7,326	4,983	3,941	2,585	1,928	1,460	1,123	721	568	467	716	112
White spruce	77,495	28,691	17,850	12,753	7,786	4,358	2,861	1,433	863	495	254	151	-
Black spruce	1,022,264	508,581	321,611	141,162	39,995	8,831	1,674	262	102	22	11	12	1
Balsam fir	953,850	521,972	234,835	116,774	50,915	20,299	6,836	1,648	429	93	30	19	-
Tamarack	350,608	158,656	97,539	58,697	23,814	8,109	2,591	840	274	39	37	12	-
Eastern redcedar	12,760	6,980	3,131	1,256	1,013	199	135	23	13	7	-	3	-
Northern white-cedar	334,576	125,689	78,316	60,063	37,249	18,709	8,100	3,823	1,612	591	268	155	1
Other softwoods	1,634	351	575	300	291	71	18	20	8	-	-	-	-
Total softwoods	3,032,291	1,422,163	810,169	447,884	203,314	85,372	34,692	14,883	6,798	3,370	1,877	1,654	115
Hardwoods													
Select white oak	176,496	65,987	37,980	28,962	16,452	10,985	6,685	3,975	2,506	1,466	710	741	47
Select red oak	100,388	26,688	10,891	11,730	15,225	14,073	8,934	5,421	3,431	1,930	1,015	980	70
Other red oak	5,300	1,464	672	762	1,115	335	340	203	179	74	66	85	5
Select hickory	8,789	4,833	2,183	560	469	306	232	132	46	21	3	4	-
Other hickory	7,531	4,559	1,083	978	554	219	83	43	6	4	2	-	-
Basswood	176,542	76,522	31,583	24,183	16,864	12,378	6,729	3,918	2,057	1,212	548	516	32
Yellow birch	9,543	5,731	1,733	839	414	258	158	182	91	54	46	36	1
Hard maple	248,742	138,760	51,247	33,508	13,111	5,439	3,084	1,618	1,027	530	226	185	7
Soft maple	260,330	128,118	69,289	40,566	13,608	5,200	1,674	816	403	226	164	202	64
Elm	159,088	87,646	35,941	17,916	7,748	4,437	2,520	1,126	768	404	261	284	37
Black ash	497,620	268,596	112,616	59,545	32,234	14,510	6,192	2,523	898	329	112	65	-
White & green ash	81,551	47,222	13,868	7,616	5,173	3,490	1,941	1,105	576	271	161	107	21
Cottonwood	2,631	663	376	193	275	296	169	109	119	84	94	166	87
Willow	4,294	2,190	93	225	482	483	327	203	127	95	33	32	4
Hackberry	13,350	9,931	2,036	779	280	126	71	56	26	28	10	6	1
Balsam poplar	254,930	136,649	44,071	28,769	20,500	13,386	6,622	2,972	1,213	515	149	82	2
Bigtooth aspen	69,060	38,115	7,263	5,600	5,706	5,384	3,953	1,883	769	285	73	28	1
Quaking aspen	1,900,116	1,205,275	278,120	143,935	107,954	80,363	47,657	22,995	9,422	2,979	939	473	4
Paper birch	527,199	178,191	127,580	102,206	67,737	33,246	12,179	4,170	1,259	458	97	73	3
Black cherry	31,856	26,469	3,290	947	609	277	144	69	28	19	4	-	-
Black walnut	2,052	702	371	73	448	114	110	92	77	45	9	11	-
Butternut	2,022	736	511	31	276	182	136	60	44	26	14	6	-
Other hardwoods	49,898	32,969	8,152	4,176	2,218	1,414	446	276	146	61	28	11	1
Total hardwoods	4,589,328	2,488,016	840,949	514,099	329,452	206,901	110,386	53,947	25,218	11,116	4,764	4,093	387
All species	7,621,619	3,910,179	1,651,118	961,983	532,766	292,273	145,078	68,830	32,016	14,486	6,641	5,747	502

Table 12. -- Net volume of growing stock on timberland by species group and diameter class, Minnesota, 1990

(In thousand cubic feet)

Species group	All classes	Diameter class (inches at breast height)									
		5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods											
Jack pine	553,019	75,689	134,713	145,501	100,294	60,316	23,311	8,775	2,525	1,895	-
Red pine	585,215	56,562	82,073	79,422	74,811	74,997	69,675	59,730	43,826	44,016	103
White pine	263,829	8,879	13,838	18,447	23,378	26,976	24,401	26,200	28,264	72,623	20,823
White spruce	296,414	33,588	46,904	48,045	49,850	36,653	30,881	23,020	15,196	12,277	-
Black spruce	746,180	377,748	233,990	93,462	27,981	6,569	3,680	989	599	1,070	92
Balsam fir	963,830	293,095	290,769	208,324	110,869	39,422	14,250	4,117	1,724	1,260	-
Tamarack	475,656	164,341	147,301	87,282	43,316	19,906	8,999	1,678	1,966	867	-
Eastern redcedar	14,959	3,479	5,720	1,989	2,236	607	418	302	-	208	-
Northern white-cedar	744,792	133,887	182,201	161,670	108,007	74,849	42,028	20,698	11,819	9,563	70
Other softwoods	3,743	681	1,431	680	277	439	235	-	-	-	-
Total softwoods	4,647,637	1,147,949	1,138,940	844,822	541,019	340,734	217,878	145,509	105,919	143,779	21,088
Hardwoods											
Select white oak	647,392	63,413	85,122	100,137	95,350	82,575	71,742	54,832	33,920	53,241	7,060
Select red oak	818,970	28,667	81,410	134,415	135,126	119,548	103,803	78,259	52,525	74,871	10,346
Other red oak	36,749	1,869	5,408	3,127	4,788	4,255	4,951	2,692	3,180	5,794	685
Select hickory	16,348	1,362	2,503	2,964	3,673	2,997	1,595	867	147	240	-
Other hickory	9,822	2,248	2,853	1,996	1,304	937	205	181	98	-	-
Basswood	692,132	65,307	101,976	133,469	109,971	93,014	66,561	50,473	28,686	38,412	4,263
Yellow birch	21,876	2,027	2,305	2,599	2,495	3,851	2,460	2,010	2,013	2,041	75
Hard maple	403,671	89,456	79,329	58,128	52,147	39,403	33,883	23,359	12,885	14,010	1,071
Soft maple	345,140	102,602	79,344	54,167	28,322	20,113	13,278	10,125	8,891	17,098	11,200
Elm	269,571	39,581	42,450	43,286	38,969	25,471	23,553	16,130	13,172	21,409	5,550
Black ash	700,461	153,097	186,945	149,158	99,879	59,078	28,626	13,542	5,749	4,387	-
White & green ash	186,757	18,274	29,120	34,546	29,952	25,480	18,040	11,096	8,724	8,577	2,948
Cottonwood	52,385	452	1,291	2,775	2,740	2,437	3,768	3,460	4,738	13,538	17,186
Willow	29,374	493	2,495	4,476	4,821	4,461	3,795	3,708	1,683	2,686	756
Hackberry	9,885	1,898	1,456	1,180	1,030	1,341	770	1,099	498	456	157
Balsam poplar	595,247	76,527	120,224	140,848	108,358	71,385	40,383	22,163	8,193	6,871	295
Bigtooth aspen	279,740	16,538	37,128	61,382	69,847	47,990	27,229	13,151	4,305	2,048	122
Quaking aspen	3,818,495	383,975	653,941	871,447	804,576	564,479	316,852	133,039	52,978	36,557	651
Paper birch	1,458,718	294,044	424,051	361,138	206,853	100,929	41,240	19,446	5,225	5,302	490
Black cherry	15,688	2,771	3,786	3,055	2,461	1,729	925	777	184	-	-
Black walnut	14,163	172	2,868	1,354	2,005	2,255	2,469	1,789	503	748	-
Butternut	11,150	119	1,828	2,094	2,270	1,404	1,315	949	738	433	-
Other hardwoods	51,687	8,786	11,416	12,156	5,954	5,457	3,885	2,190	1,157	584	102
Total hardwoods	10,485,421	1,353,678	1,959,249	2,179,897	1,812,891	1,280,589	811,328	465,337	250,192	309,303	62,957
All species	15,133,058	2,501,627	3,098,189	3,024,719	2,353,910	1,621,323	1,029,206	610,846	356,111	453,082	84,045

Table 13. -- Net volume of growing stock in the saw-log portion of sawtimber trees on timberland by species group and diameter class, Minnesota, 1990

(In thousand cubic feet)

Species group	All classes	Diameter class (inches at breast height)							
		9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods									
Jack pine	292,482	118,524	87,466	53,680	20,909	7,906	2,280	1,717	-
Red pine	410,437	69,903	69,047	69,846	64,827	55,458	40,592	40,669	95
White pine	208,232	14,285	19,644	23,218	21,204	22,875	24,738	63,801	18,467
White spruce	195,305	41,272	45,197	33,705	28,489	21,259	14,032	11,351	-
Black spruce	123,781	84,922	26,521	6,253	3,489	938	566	1,005	87
Balsam fir	319,040	168,719	96,252	34,976	12,724	3,689	1,547	1,133	-
Tamarack	143,988	74,271	39,060	18,232	8,269	1,544	1,811	801	-
Eastern redcedar	4,982	1,617	1,970	547	380	276	-	192	-
Northern white-cedar	366,758	131,131	93,693	66,390	37,611	18,591	10,641	8,637	64
Other softwoods	1,398	550	244	392	212	-	-	-	-
Total softwoods	2,066,403	705,194	479,094	307,239	198,114	132,536	96,207	129,306	18,713
Hardwoods									
Select white oak	287,774	-	61,228	58,890	53,279	41,577	25,991	41,261	5,548
Select red oak	416,955	-	87,048	85,623	77,549	59,630	40,482	58,414	8,209
Other red oak	19,464	-	3,059	3,064	3,720	2,060	2,458	4,558	545
Select hickory	6,225	-	2,176	1,997	1,128	634	108	182	-
Other hickory	1,723	-	756	622	143	129	73	-	-
Basswood	289,173	-	73,870	68,791	50,994	39,250	22,512	30,338	3,418
Yellow birch	11,532	-	1,726	2,895	1,932	1,615	1,625	1,677	62
Hard maple	127,480	-	33,817	28,394	25,483	17,916	9,988	11,017	865
Soft maple	78,600	-	17,925	14,263	9,814	7,640	6,794	13,279	8,885
Elm	100,244	-	23,638	17,468	16,934	11,855	9,820	16,227	4,302
Black ash	154,048	-	68,437	44,509	22,300	10,730	4,562	3,510	-
White & green ash	76,960	-	20,097	18,749	13,736	8,556	6,782	6,706	2,334
Cottonwood	35,756	-	1,603	1,585	2,650	2,506	3,503	10,291	13,618
Willow	14,934	-	2,772	2,941	2,656	2,674	1,241	2,054	596
Hackberry	3,779	-	617	935	560	822	376	347	122
Balsam poplar	184,601	-	72,604	52,431	30,610	17,051	6,328	5,347	230
Bigtooth aspen	120,583	-	48,123	36,002	21,053	10,298	3,386	1,623	98
Quaking aspen	1,383,916	-	547,600	419,415	242,838	103,341	41,444	28,763	515
Paper birch	258,512	-	133,323	71,706	30,489	14,603	3,965	4,046	380
Black cherry	4,259	-	1,564	1,252	698	601	144	-	-
Black walnut	7,452	-	1,401	1,701	1,933	1,418	399	600	-
Butternut	5,289	-	1,525	1,046	1,030	753	586	349	-
Other hardwoods	14,152	-	3,983	4,036	2,972	1,703	914	463	81
Total hardwoods	3,603,411	-	1,208,892	938,315	614,501	357,362	193,481	241,052	49,808
All species	5,669,814	705,194	1,687,986	1,245,554	812,615	489,898	289,688	370,358	68,521

Table 14. -- Net volume of sawtimber on timberland by species group and diameter class, Minnesota, 1990

(In thousand board feet)[1]

Species group	All classes	Diameter class (inches at breast height)							
		9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-28.9	29.0+
Softwoods									
Jack pine	1,706,422	700,534	498,063	310,311	124,150	48,149	14,213	11,002	-
Red pine	2,444,196	405,092	390,400	404,170	386,557	339,850	254,728	262,760	639
White pine	1,297,353	85,668	112,024	134,422	126,281	140,122	155,026	417,611	126,199
White spruce	1,152,492	241,082	256,462	194,920	169,617	129,802	87,629	72,980	-
Black spruce	709,531	486,858	149,462	36,103	20,777	5,716	3,521	6,519	575
Balsam fir	1,859,325	995,007	547,062	202,290	75,588	22,558	9,642	7,178	-
Tamarack	835,291	433,159	221,822	105,424	49,096	9,401	11,262	5,127	-
Eastern redcedar	29,531	9,890	11,319	3,173	2,247	1,673	-	1,229	-
Northern white-cedar	2,193,168	807,416	543,805	385,882	222,725	112,388	65,654	54,877	421
Other softwoods	8,140	3,241	1,386	2,256	1,257	-	-	-	-
Total softwoods	12,235,449	4,167,947	2,731,805	1,778,951	1,178,295	809,659	601,675	839,283	127,834
Hardwoods									
Select white oak	1,823,231	-	394,016	366,059	331,155	260,904	165,200	268,452	37,445
Select red oak	2,638,204	-	557,097	530,963	481,821	374,606	257,740	380,599	55,378
Other red oak	123,676	-	19,791	19,038	23,126	12,894	15,618	29,553	3,656
Select hickory	39,396	-	14,110	12,445	7,007	3,973	687	1,174	-
Other hickory	10,979	-	4,921	3,893	889	812	464	-	-
Basswood	1,822,679	-	469,477	425,607	316,878	246,773	143,271	197,675	22,998
Yellow birch	72,782	-	11,060	18,035	12,008	10,115	10,318	10,834	412
Hard maple	804,576	-	216,336	175,979	158,295	112,696	63,687	71,716	5,867
Soft maple	503,438	-	115,015	88,508	60,995	48,034	43,255	86,885	60,746
Elm	638,862	-	153,133	108,673	105,299	74,404	62,424	105,650	29,279
Black ash	968,817	-	435,586	275,472	138,541	67,382	29,079	22,757	-
White & green ash	485,137	-	127,394	115,861	85,349	53,780	43,227	43,767	15,759
Cottonwood	235,374	-	10,308	9,868	16,501	15,739	22,277	67,273	93,408
Willow	95,126	-	18,090	18,330	16,519	16,796	7,881	13,450	4,060
Hackberry	23,940	-	4,051	5,802	3,476	5,159	2,392	2,238	822
Balsam poplar	1,157,379	-	459,496	323,874	190,173	107,125	40,352	34,797	1,562
Bigtooth aspen	752,257	-	301,943	221,893	130,761	64,831	21,628	10,537	664
Quaking aspen	8,652,491	-	3,451,525	2,587,974	1,507,686	650,253	264,486	187,091	3,476
Paper birch	1,626,662	-	847,796	443,866	189,306	91,673	25,221	26,249	2,551
Black cherry	26,808	-	10,044	7,751	4,331	3,769	913	-	-
Black walnut	46,779	-	8,847	10,530	12,028	8,897	2,551	3,926	-
Butternut	33,340	-	9,733	6,475	6,397	4,722	3,730	2,283	-
Other hardwoods	89,096	-	25,538	25,070	18,466	10,706	5,794	2,981	541
Total hardwoods	22,671,029	-	7,665,307	5,801,966	3,817,007	2,246,043	1,232,195	1,569,887	338,624
All species	34,906,478	4,167,947	10,397,112	7,580,917	4,995,302	3,055,702	1,833,870	2,409,170	466,458

[1] International 1/4-inch rule.

Table 15. -- Net volume of sawtimber on timberland by species group, grade[1], diameter class, and Forest Survey Unit, Minnesota, 1990

(In thousand board feet)[2]

Aspen-Birch Unit

Species group	Log grade 1					Log grade 2					Log grade 3					Log grade 4				
		Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)			
	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+
Softwoods																				
Jack pine	7,874	7,874	-	-	-	39,900	30,156	9,744	-	-	529,063	458,243	58,981	8,041	3,798	-	-	-	-	-
Red pine	72,349	19,956	25,224	9,090	18,079	113,272	42,453	42,188	19,631	9,000	600,071	393,915	144,963	27,206	33,987	-	-	-	-	-
White pine	140,297	7,390	18,842	12,857	101,208	182,049	51,830	29,407	33,715	67,097	309,724	92,319	86,222	37,057	94,126	16,549	1,572	6,479	8,498	-
White spruce	13,174	-	9,274	3,900	-	48,743	14,271	22,137	3,473	8,862	746,216	480,448	178,271	46,330	41,167	-	-	-	-	-
Black spruce	-	-	-	-	-	7,785	2,506	5,279	-	-	532,517	512,685	17,225	-	2,607	-	-	-	-	-
Balsam fir	-	-	-	-	-	7,338	3,258	4,080	-	-	1,121,676	1,072,406	49,270	-	-	-	-	-	-	-
Tamarack	-	-	-	-	-	19,367	16,652	2,715	-	-	316,221	294,637	21,584	-	-	-	-	-	-	-
Northern white-cedar	13,366	-	3,143	3,905	6,318	132,316	60,585	54,471	8,870	8,390	1,352,442	1,111,787	176,279	33,839	30,537	-	-	-	-	-
Other softwoods	-	-	-	-	-	-	-	-	-	-	430	430	-	-	-	-	-	-	-	-
Total softwoods	247,060	35,220	56,483	29,752	125,605	550,770	221,711	170,021	65,689	93,349	5,508,360	4,416,870	732,795	152,473	206,222	16,549	1,572	6,479	8,498	-
		Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)			
	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+
Hardwoods																				
Select white oak	-	-	-	-	-	-	-	-	-	-	19,232	19,232	-	-	-	9,213	2,017	-	-	7,196
Select red oak	3,174	-	3,174	-	-	11,133	5,468	5,665	-	-	22,589	15,434	7,155	-	-	1,484	620	864	-	-
Other red oak	-	-	-	-	-	-	-	-	-	-	528	528	-	-	-	-	-	-	-	-
Basswood	24,249	5,692	7,356	6,257	4,944	25,346	12,141	10,229	-	2,976	79,845	53,105	19,376	3,213	4,151	4,386	2,861	1,525	-	-
Yellow birch	14,886	-	3,179	2,471	9,236	9,159	2,971	3,238	1,708	1,242	20,524	13,021	6,691	237	575	5,565	1,156	1,972	2,437	-
Hard maple	13,214	-	7,220	2,173	3,821	26,247	11,294	10,044	-	4,909	103,208	68,302	20,484	8,791	5,631	12,261	10,375	1,886	-	-
Soft maple	1,788	-	1,788	-	-	4,750	4,750	-	-	-	48,960	33,421	10,220	5,319	-	16,630	10,487	6,143	-	-
Elm	12,421	-	7,653	4,768	-	18,287	9,668	5,526	-	3,093	23,327	8,173	-	3,690	11,464	6,295	-	-	-	6,295
Black ash	12,923	5,747	2,488	4,688	-	60,574	43,375	11,418	1,173	4,608	229,382	192,408	36,974	-	-	20,267	15,311	4,956	-	-
White & green ash	1,588	-	1,588	-	-	4,654	3,688	966	-	-	11,185	9,921	1,264	-	-	1,843	1,843	-	-	-
Cottonwood	-	-	-	-	-	-	-	-	-	-	1,829	1,829	-	-	-	-	-	-	-	-
Willow	-	-	-	-	-	-	-	-	-	-	698	698	-	-	-	-	-	-	-	-
Balsam poplar	31,654	2,333	19,355	2,898	7,068	67,143	34,622	29,036	3,485	-	360,420	271,177	69,170	12,077	7,996	43,030	40,643	2,387	-	-
Bigtooth aspen	2,016	1,050	966	-	-	29,880	9,912	18,607	1,361	-	54,835	47,923	6,912	-	-	2,315	2,315	-	-	-
Quaking aspen	152,409	16,079	104,384	19,187	12,759	474,654	259,954	170,902	26,397	17,401	2,470,424	1,852,633	507,864	60,174	49,753	222,401	175,312	38,134	3,930	5,025
Paper birch	28,153	4,690	19,892	1,190	2,381	129,097	87,132	39,040	2,925	-	559,766	461,629	80,250	7,085	10,802	55,179	39,567	10,158	3,918	1,536
Other hardwoods	-	-	-	-	-	-	-	-	-	-	139	139	-	-	-	-	-	-	-	-
Total hardwoods	298,475	35,591	179,043	43,632	40,209	860,924	484,975	304,671	37,049	34,229	4,006,891	3,049,573	766,360	100,586	90,372	400,869	302,507	68,025	10,285	20,052
All species	545,535	70,811	235,526	73,384	165,814	1,411,694	706,686	474,692	102,738	127,578	9,515,251	7,466,443	1,499,155	253,059	296,594	417,418	304,079	74,504	18,783	20,052

(Table 15 continued on next page)

(Table 15 continued)

Northern Pine Unit

Species group	Log grade 1					Log grade 2					Log grade 3					Log grade 4				
		Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)			
	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+
Softwoods																				
Jack pine	1,552	-	-	1,552	-	69,246	52,057	17,189	-	-	1,017,181	919,730	85,449	4,835	7,167	-	-	-	-	-
Red pine	173,815	7,398	52,480	49,444	64,493	338,333	66,212	166,783	49,580	55,758	1,038,803	576,942	283,923	94,865	83,073	1,028	1,028	-	-	-
White pine	85,633	13,219	9,930	5,491	56,993	146,962	19,681	49,274	18,811	59,196	205,538	96,577	38,483	18,180	52,298	98,053	16,764	1,810	5,821	73,658
White spruce	5,357	-	-	2,664	2,693	36,197	9,737	19,360	-	7,100	279,906	179,420	63,280	26,093	11,113	2,278	2,278	-	-	-
Black spruce	-	-	-	-	-	6,278	3,953	2,325	-	-	160,107	158,396	1,711	-	-	-	-	-	-	-
Balsam fir	-	-	-	-	-	15,373	11,076	4,297	-	-	687,589	649,280	38,309	-	-	-	-	-	-	-
Tamarack	-	-	-	-	-	18,785	16,007	-	2,778	-	395,356	359,270	31,303	2,210	2,573	-	-	-	-	-
Northern white-cedar	1,672	-	-	-	1,672	27,804	10,542	5,759	5,412	6,091	658,645	549,077	92,405	14,160	3,003	6,923	4,830	2,093	-	-
Other softwoods	-	-	-	-	-	-	-	-	-	-	403	403	-	-	-	-	-	-	-	-
Total softwoods	268,029	20,617	62,410	59,151	125,851	658,978	189,265	264,987	76,581	128,145	4,443,528	3,489,095	634,863	160,343	159,227	108,282	24,900	3,903	5,821	73,658
		Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)			
	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+
Hardwoods																				
Select white oak	20,952	1,688	6,331	3,606	9,327	85,200	25,454	41,627	7,479	10,640	272,824	178,260	65,799	13,140	15,625	44,855	27,462	10,846	3,349	3,198
Select red oak	33,652	3,045	19,448	6,296	4,863	160,395	59,146	64,198	19,179	17,872	535,319	378,008	117,703	13,897	25,711	53,374	22,280	19,786	2,991	8,317
Other red oak	-	-	-	-	-	-	-	-	-	-	10,439	9,357	-	-	1,082	2,015	2,015	-	-	-
Other hickory	-	-	-	-	-	-	-	-	-	-	363	363	-	-	-	-	-	-	-	-
Basswood	151,239	25,109	84,889	25,306	15,935	264,353	167,761	74,076	3,640	18,876	365,424	289,323	63,439	11,456	1,206	10,950	5,779	3,242	-	1,929
Yellow birch	2,330	-	2,330	-	-	4,743	-	4,743	-	-	12,695	4,057	1,937	5,735	966	1,917	1,917	-	-	-
Hard maple	64,966	1,300	49,580	10,348	3,738	148,355	55,696	65,515	20,559	6,585	153,641	106,411	34,190	2,857	10,183	8,511	7,471	1,040	-	-
Soft maple	33,900	1,715	6,357	6,713	19,115	41,498	15,969	13,369	4,992	7,168	90,782	60,220	13,592	4,520	12,450	1,102	1,102	-	-	-
Elm	14,263	2,381	10,109	-	1,773	83,178	22,057	35,591	8,122	17,408	158,843	94,195	35,505	12,599	16,544	-	-	-	-	-
Black ash	53,178	3,783	43,716	5,679	-	154,247	93,100	42,917	4,679	13,551	275,720	251,661	22,431	1,628	-	9,764	9,764	-	-	-
White & green ash	6,984	614	3,514	-	2,856	24,097	12,584	8,775	2,738	-	54,298	42,691	8,882	2,725	-	1,483	1,483	-	-	-
Cottonwood	-	-	-	-	-	-	-	-	-	-	466	466	-	-	-	-	-	-	-	-
Willow	-	-	-	-	-	-	-	-	-	-	343	343	-	-	-	-	-	-	-	-
Balsam poplar	19,638	1,537	12,649	1,713	3,739	90,701	21,239	58,959	1,215	9,288	444,763	351,421	73,566	15,022	4,754	31,022	19,443	10,019	1,560	-
Bigtooth aspen	22,969	5,303	10,603	1,292	5,771	108,785	54,974	44,855	8,211	745	344,429	255,759	80,489	6,242	1,939	14,320	9,503	4,817	-	-
Quaking aspen	135,723	5,663	94,710	17,749	17,601	724,003	363,139	301,150	24,623	35,091	3,338,907	2,515,104	685,585	95,130	43,088	269,295	188,342	77,704	3,249	-
Paper birch	34,556	8,386	20,976	2,383	2,811	147,862	97,256	40,361	2,722	7,523	519,111	470,213	45,218	3,680	-	35,880	28,553	7,327	-	-
Butternut	2,505	-	1,212	-	1,293	-	-	-	-	-	1,096	1,096	-	-	-	-	-	-	-	-
Other hardwoods	-	-	-	-	-	-	-	-	-	-	3,755	3,755	-	-	-	-	-	-	-	-
Total hardwoods	596,855	60,524	366,424	81,085	88,822	2,037,417	988,375	796,136	108,159	144,747	6,583,218	5,012,703	1,248,336	188,631	133,548	484,488	325,114	134,781	11,149	13,444
All species	864,884	81,141	428,834	140,236	214,673	2,696,395	1,177,640	1,061,123	184,740	272,892	11,026,746	8,501,798	1,883,199	348,974	292,775	592,770	350,014	138,684	16,970	87,102

(Table 15 continued on next page)

(Table 15 continued)

Central Hardwood Unit

Species group	Log grade 1 Total	Log grade 1 Diameter class (inches at breast height) 9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Log grade 2 Total	Log grade 2 Diameter class (inches at breast height) 9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Log grade 3 Total	Log grade 3 Diameter class (inches at breast height) 9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Log grade 4 Total	Log grade 4 Diameter class (inches at breast height) 9.0-14.9	15.0-18.9	19.0-20.9	21.0+
Softwoods																				
Jack pine	507	507	-	-	-	1,894	1,894	-	-	-	38,285	36,720	1,565	-	-	-	-	-	-	-
Red pine	6,171	3,288	335	2,548	-	5,842	1,341	1,837	-	2,664	90,810	67,659	11,646	6,591	4,914	-	-	-	-	-
White pine	8,629	495	2,945	5,189	-	52,398	10,268	11,174	8,948	22,008	34,804	11,896	8,616	1,542	12,750	13,205	1,281	2,990	-	8,934
White spruce	-	-	-	-	-	-	-	-	-	-	16,945	13,948	2,997	-	-	-	-	-	-	-
Black spruce	-	-	-	-	-	-	-	-	-	-	2,844	2,844	-	-	-	-	-	-	-	-
Balsam fir	-	-	-	-	-	-	-	-	-	-	27,349	24,834	2,515	-	-	-	-	-	-	-
Tamarack	-	-	-	-	-	2,761	2,761	-	-	-	75,060	72,089	2,971	-	-	6,009	6,009	-	-	-
Eastern redcedar	-	-	-	-	-	-	-	-	-	-	18,868	18,264	604	-	-	-	-	-	-	-
Other softwoods	-	-	-	-	-	-	-	-	-	-	7,307	7,307	-	-	-	-	-	-	-	-
Total softwoods	15,307	4,290	3,280	7,737	-	62,895	16,264	13,011	8,948	24,672	312,272	255,561	30,914	8,133	17,664	19,214	7,290	2,990	-	8,934
	Tree grade [1] Total	Tree grade [1] Diameter class (inches at breast height) 11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Tree grade [2] Total	Tree grade [2] Diameter class (inches at breast height) 11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Tree grade [3] Total	Tree grade [3] Diameter class (inches at breast height) 11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Tie and timber Total	Tie and timber Diameter class (inches at breast height) 11.0-14.9	15.0-18.9	19.0-20.9	21.0+
Hardwoods																				
Select white oak	19,176	-	4,107	-	15,069	138,865	26,662	64,781	13,121	34,301	358,031	150,702	108,048	28,785	70,496	418,107	206,730	146,569	37,355	27,453
Select red oak	99,374	-	34,091	20,686	44,597	430,261	80,414	170,695	68,422	110,730	635,918	251,630	182,439	70,169	131,680	542,852	260,963	191,614	40,175	50,100
Other red oak	6,074	-	-	2,295	3,779	13,371	1,066	3,231	6,009	3,065	22,754	9,310	6,601	-	6,843	62,794	24,547	19,578	4,715	13,954
Select hickory	2,193	-	2,193	-	-	8,655	4,048	4,607	-	-	14,739	11,352	3,387	-	-	13,067	10,959	2,108	-	-
Other hickory	-	-	-	-	-	1,310	-	1,310	-	-	2,440	2,440	-	-	-	4,149	-	4,149	-	-
Basswood	141,086	2,168	75,563	31,266	32,089	221,491	109,456	68,974	12,104	30,957	240,656	147,562	42,885	11,760	38,449	23,831	16,022	5,890	-	1,919
Yellow birch	-	-	-	-	-	-	-	-	-	-	963	963	-	-	-	-	-	-	-	-
Hard maple	6,205	1,514	4,691	-	-	47,112	12,400	19,323	11,117	4,272	112,972	56,814	37,063	7,122	11,973	67,365	36,742	10,726	2,866	17,031
Soft maple	9,824	-	-	-	9,824	15,103	9,794	5,309	-	-	78,415	31,938	14,311	16,337	15,829	124,985	25,509	31,784	4,788	62,904
Elm	27,516	2,924	-	5,614	18,978	48,130	17,885	21,258	-	8,987	85,031	52,230	10,858	10,574	11,369	77,393	37,581	26,112	13,700	-
Black ash	9,980	3,546	-	6,434	-	33,956	18,558	13,531	1,867	-	76,329	70,238	1,700	-	4,391	26,752	11,287	15,465	-	-
White & green ash	47,190	3,050	17,617	9,175	17,348	35,749	19,996	5,807	2,674	7,272	68,403	39,969	22,767	2,108	3,559	55,272	43,255	6,412	3,867	1,738
Cottonwood	47,936	-	2,017	6,258	39,661	28,502	2,979	5,302	3,817	16,404	18,160	2,087	5,400	3,378	7,295	6,241	1,145	-	-	5,096
Willow	-	-	-	-	-	-	-	-	-	-	13,477	-	13,477	-	-	22,453	7,559	11,551	-	3,343
Hackberry	-	-	-	-	-	2,796	2,796	-	-	-	4,928	4,928	-	-	-	4,505	4,505	-	-	-
Balsam poplar	-	-	-	-	-	4,519	-	4,519	-	-	11,018	11,018	-	-	-	17,083	15,222	-	1,861	-
Bigtooth aspen	1,877	338	1,539	-	-	16,337	10,166	3,720	-	2,451	99,826	84,076	15,750	-	-	54,352	45,072	9,280	-	-
Quaking aspen	2,949	-	2,949	-	-	131,118	86,093	45,025	-	-	368,097	282,837	72,068	9,325	3,867	219,175	194,925	24,250	-	-
Paper birch	-	-	-	-	-	17,104	9,336	7,768	-	-	49,247	49,247	-	-	-	48,272	44,196	4,076	-	-
Black cherry	-	-	-	-	-	3,260	3,260	-	-	-	16,206	11,450	4,756	-	-	5,294	5,294	-	-	-
Black walnut	-	-	-	-	-	24,051	7,837	10,823	-	5,391	6,519	785	5,734	-	-	8,518	3,625	-	4,893	-
Butternut	-	-	-	-	-	-	-	-	-	-	7,225	7,225	-	-	-	20,863	20,863	-	-	-
Other hardwoods	-	-	-	-	-	-	-	-	-	-	24,504	18,372	6,132	-	-	25,120	14,809	10,311	-	-
Total hardwoods	421,380	13,540	144,767	81,728	181,345	1,221,690	422,746	455,983	119,131	223,830	2,315,858	1,297,173	553,376	159,558	305,751	1,848,443	1,030,810	519,875	114,220	183,538
All species	436,687	17,830	148,047	89,465	181,345	1,284,585	439,010	468,994	128,079	248,502	2,628,130	1,552,734	584,290	167,691	323,415	1,867,657	1,038,100	522,865	114,220	192,472

(Table 15 continued on next page)

(Table 15 continued)

Prairie Unit

Species group	Log grade 1 (softwoods), tree grade 1 (hardwoods)					Log grade 2 (softwoods), tree grade 2 (hardwoods)					Log grade 3 (softwoods), tree grade 3 (hardwoods)					Log grade 4				
		Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)				
	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	9.0-14.9	15.0-18.9	19.0-20.9	21.0+
Softwoods																				
Jack pine	-	-	-	-	-	-	-	-	-	-	920	920	-	-	-	-	-	-	-	-
Red pine	-	-	-	-	-	-	-	-	-	-	3,702	3,702	-	-	-	-	-	-	-	-
White pine	-	-	-	-	-	-	-	-	-	-	3,512	3,512	-	-	-	-	-	-	-	-
White spruce	-	-	-	-	-	-	-	-	-	-	3,676	3,676	-	-	-	-	-	-	-	-
Tamarack	-	-	-	-	-	-	-	-	-	-	1,732	1,732	-	-	-	-	-	-	-	-
Eastern redcedar	-	-	-	-	-	1,805	885	920	-	-	8,858	7,241	1,617	-	-	-	-	-	-	-
Total softwoods	-	-	-	-	-	1,805	885	920	-	-	22,400	20,783	1,617	-	-	-	-	-	-	-
	Tree grade [1]					Tree grade [2]					Tree grade [3]					Tie and timber				
	Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)					Diameter class (inches at breast height)				
	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+	Total	11.0-14.9	15.0-18.9	19.0-20.9	21.0+
Hardwoods																				
Select white oak	26,780	-	4,035	3,230	19,515	48,461	8,195	22,601	6,317	11,348	156,854	34,565	52,811	26,169	43,309	204,681	97,529	60,912	19,065	27,175
Select red oak	4,416	-	-	4,416	-	27,100	-	13,836	3,066	10,198	47,779	11,823	18,268	4,595	13,093	29,384	16,698	6,120	-	6,566
Other red oak	-	-	-	-	-	-	-	-	-	-	4,596	-	-	-	4,596	1,105	-	-	-	1,105
Select hickory	-	-	-	-	-	-	-	-	-	-	742	742	-	-	-	-	-	-	-	-
Other hickory	-	-	-	-	-	-	-	-	-	-	1,271	1,271	-	-	-	1,446	-	-	1,446	-
Basswood	104,438	-	45,693	5,376	53,369	66,679	28,039	17,970	13,675	6,995	92,012	33,140	35,267	16,053	7,552	6,694	4,644	2,050	-	-
Hard maple	8,464	-	8,464	-	-	11,858	6,000	5,858	-	-	12,297	12,297	-	-	-	7,900	7,900	-	-	-
Soft maple	10,943	-	-	-	10,943	4,879	-	4,879	-	-	6,075	-	-	-	6,075	13,804	7,286	6,518	-	-
Elm	2,641	-	2,641	-	-	21,210	2,668	9,538	-	9,004	23,558	8,580	1,702	5,443	7,833	36,769	9,411	6,420	2,424	18,514
Black ash	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,745	5,745	-	-	-
White & green ash	28,032	-	18,564	-	9,468	38,699	10,138	13,646	6,206	8,709	81,029	40,357	18,397	14,972	7,303	24,631	16,425	8,206	-	-
Cottonwood	25,860	-	-	4,254	21,606	36,632	-	4,905	4,180	27,547	54,639	9,655	9,536	-	35,448	15,109	2,764	4,850	-	7,495
Willow	-	-	-	-	-	7,148	3,710	-	3,438	-	-	-	-	-	-	51,007	26,405	19,799	4,803	-
Hackberry	-	-	-	-	-	4,184	4,184	-	-	-	7,527	7,527	-	-	-	-	-	-	-	-
Balsam poplar	-	-	-	-	-	-	-	-	-	-	15,109	10,085	5,024	-	-	21,279	21,279	-	-	-
Bigtooth aspen	-	-	-	-	-	-	-	-	-	-	316	316	-	-	-	-	-	-	-	-
Quaking aspen	-	-	-	-	-	-	-	-	-	-	48,273	35,727	12,546	-	-	95,063	91,860	3,203	-	-
Paper birch	-	-	-	-	-	-	-	-	-	-	2,435	2,435	-	-	-	-	-	-	-	-
Black cherry	-	-	-	-	-	-	-	-	-	-	2,048	-	2,048	-	-	-	-	-	-	-
Black walnut	-	-	-	-	-	3,497	2,320	-	1,177	-	4,194	1,544	2,650	-	-	-	-	-	-	-
Butternut	-	-	-	-	-	-	-	-	-	-	1,651	1,651	-	-	-	-	-	-	-	-
Other hardwoods	-	-	-	-	-	5,211	-	5,211	-	-	4,505	4,505	-	-	-	25,862	15,116	10,746	-	-
Total hardwoods	211,574	-	79,397	17,276	114,901	275,558	65,254	98,444	38,059	73,801	566,910	216,220	158,249	67,232	125,209	540,479	323,062	128,824	27,738	60,855
All species	211,574	-	79,397	17,276	114,901	277,363	66,139	99,364	38,059	73,801	589,310	237,003	159,866	67,232	125,209	540,479	323,062	128,824	27,738	60,855

[1] Two grading systems were used in Minnesota:
Log grades were used for softwoods throughout the State and for hardwoods in the Aspen-Birch and Northern Pine Units. Tree grades were used for hardwoods in the Central Hardwood and Prairie Units.

[2] International 1/4-inch rule.

Table 16. -- Net volume of growing stock and sawtimber on timberland by Forest Survey Unit, county, and major species group, Minnesota, 1990

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Aspen-Birch Unit	*(In thousand cubic feet)*					*(In thousand board feet)1*				
Carlton	314,830	19,392	62,883	170,623	61,932	588,848	94,935	139,964	275,904	78,045
Cook	696,223	43,733	297,754	308,185	46,551	1,660,290	182,142	795,466	585,628	97,054
Koochiching	1,254,527	47,967	615,923	493,726	96,911	2,334,281	170,007	1,118,523	900,814	144,937
Lake	840,318	97,996	295,841	376,658	69,823	1,855,088	364,487	734,806	637,737	118,058
St. Louis	2,506,001	266,650	773,545	1,320,127	145,679	5,451,391	1,200,007	1,522,402	2,552,104	176,878
Total	5,611,899	475,738	2,045,946	2,669,319	420,896	11,889,898	2,011,578	4,311,161	4,952,187	614,972
Northern Pine Unit										
Aitkin	771,255	22,462	134,400	400,610	213,783	1,707,592	76,346	256,499	920,685	454,062
Becker	423,643	36,727	31,714	244,768	110,434	1,000,722	144,495	71,962	522,004	262,261
Beltrami	920,868	92,419	205,554	520,897	101,998	2,038,972	381,944	400,995	1,092,030	164,003
Cass	1,066,775	178,963	119,076	580,022	188,714	2,613,867	708,414	269,212	1,277,205	359,036
Clearwater	351,565	30,858	36,665	233,331	50,711	777,026	123,064	102,542	446,816	104,604
Crow Wing	479,142	73,574	23,542	234,505	147,521	1,095,793	247,743	49,164	477,938	320,948
Hubbard	457,600	116,763	33,260	238,674	68,903	977,854	357,103	100,867	399,400	120,484
Itasca	1,451,350	199,002	354,918	743,283	154,147	3,620,149	853,970	763,735	1,739,299	263,145
Lake of the Woods	307,883	29,716	128,171	138,604	11,392	555,098	98,248	193,300	245,865	17,685
Mahnomen	138,172	1,692	1,207	95,279	39,994	260,533	7,577	3,124	187,099	62,733
Roseau	161,394	22,371	42,448	85,320	11,255	330,446	81,961	87,359	146,356	14,770
Wadena	95,212	39,415	3,058	30,951	21,788	202,743	95,682	3,511	47,209	56,341
Total	6,624,859	843,962	1,114,013	3,546,244	1,120,640	15,180,795	3,176,547	2,302,270	7,501,906	2,200,072
Central Hardwood Unit										
Anoka-Dakota-Ramsey-Washington	62,436	849	233	19,924	41,430	187,186	1,091	219	45,636	140,240
Benton-Sherburne	71,622	10,706	285	12,367	48,264	178,946	24,175	801	23,052	130,918
Carver-Hennepin-Scott	46,493	-	441	14,569	31,483	168,951	-	941	51,238	116,772
Chisago-Isanti	89,426	13,873	2,832	29,318	43,403	211,040	11,134	4,072	54,478	141,356
Douglas-Todd	129,016	1,440	4,912	51,566	71,098	382,643	5,955	16,120	132,439	228,129
Fillmore-Olmsted	163,447	1,026	2,212	39,923	120,286	548,129	5,594	5,017	111,407	426,111
Goodhue	93,782	1,108	809	41,280	50,585	328,041	4,942	2,450	125,498	195,151
Houston	153,188	1,517	1,931	50,082	99,658	512,930	7,412	2,738	153,105	349,675
Kanabec	132,279	1,873	5,234	71,276	53,896	292,810	8,843	5,587	136,653	141,727
Le Sueur-Rice	49,396	-	698	25,472	23,226	181,223	-	718	94,402	86,103
Mille Lacs	144,213	491	2,109	78,027	63,586	300,113	-	3,084	160,424	136,605
Morrison	197,856	18,729	4,873	100,603	73,651	428,059	65,200	8,405	157,738	196,716
Otter Tail	200,401	2,438	11,198	88,550	98,215	529,429	6,231	34,091	230,997	258,110
Pine	462,896	29,004	30,192	303,767	99,933	874,867	112,026	55,781	513,208	193,852
Stearns	61,795	-	2,770	29,890	29,135	175,087	-	5,859	83,425	85,803
Wabasha	74,695	136	-	29,996	44,563	237,818	666	-	77,715	159,437
Winona	157,509	1,272	747	44,250	111,240	537,186	6,583	2,336	119,474	408,793
Wright	40,477	-	1,174	19,857	19,446	142,601	-	1,617	65,392	75,592
Total	2,330,927	84,462	72,650	1,050,717	1,123,098	6,217,059	259,852	149,836	2,336,281	3,471,090

(Table 16 continued on next page)

(Table 16 continued)

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Prairie Unit			*(In thousand cubic feet)*					*(In thousand board feet)1*		
Blue Earth-Fairbault	42,483	-	2,029	27,395	13,059	160,457	-	4,412	105,827	50,218
Clay-Norman	50,490	-	-	17,881	32,609	145,407	-	-	44,036	101,371
Eastern Group[2]	50,645	-	102	12,318	38,225	203,447	-	515	42,863	160,069
Kandiyohi-Meeker	43,605	-	272	21,213	22,120	168,224	-	-	83,057	85,167
Kittson	42,598	-	-	28,674	13,924	51,737	-	-	19,784	31,953
Marshall	75,266	-	3,782	58,549	12,935	98,440	-	2,717	61,639	34,084
Northern Group[3]	60,018	-	200	36,525	23,293	229,625	-	544	134,590	94,491
Pennington-Red Lake	47,133	-	-	30,128	17,005	87,529	-	-	41,454	46,075
Polk	67,677	762	98	39,987	26,830	168,257	4,181	530	100,460	63,086
Southern Group[4]	37,678	-	2,327	18,368	16,983	143,659	-	5,192	73,912	64,555
Western Group[5]	47,780	882	412	20,207	26,279	161,944	3,953	2,161	70,360	85,470
Total	565,373	1,644	9,222	311,245	243,262	1,618,726	8,134	16,071	777,982	816,539
All counties	15,133,058	1,405,806	3,241,831	7,577,525	2,907,896	34,906,478	5,456,111	6,779,338	15,568,356	7,102,673

[1]International 1/4-inch rule.

[2]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[3]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[4]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[5]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 17. -- Net volume of all live trees and salvable dead trees on timberland by class of timber and major species group, Minnesota, 1990

(In thousand cubic feet)

Class of timber	All species	Major species group			
		Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Live trees					
Growing-stock trees					
Sawtimber					
Saw-log portion	5,669,814	912,549	1,153,854	2,479,646	1,123,765
Upper stem portion	1,683,531	119,391	174,954	964,285	424,901
Total	7,353,345	1,031,940	1,328,808	3,443,931	1,548,666
Poletimber	7,779,713	373,866	1,913,023	4,133,594	1,359,230
All growing-stock trees	15,133,058	1,405,806	3,241,831	7,577,525	2,907,896
Cull trees					
Short-log trees	302,258	7,609	23,961	128,545	142,143
Rough trees [1]					
Sawtimber size	581,278	15,884	50,521	244,881	269,992
Poletimber size	631,113	10,418	71,216	338,051	211,428
Total	1,212,391	26,302	121,737	582,932	481,420
Rotten trees [1]					
Sawtimber size	311,734	3,535	42,798	195,953	69,448
Poletimber size	98,669	552	18,328	64,920	14,869
Total	410,403	4,087	61,126	260,873	84,317
All cull trees	1,925,052	37,998	206,824	972,350	707,880
Salvable dead trees					
Sawtimber size	150,011	8,400	23,343	107,315	10,953
Poletimber size	113,324	3,362	22,387	77,385	10,190
All salvable dead trees	263,335	11,762	45,730	184,700	21,143
All classes	17,321,445	1,455,566	3,494,385	8,734,575	3,636,919

[1] Includes all noncommercial species.

Table 18. -- Net volume of all live trees and growing-stock trees on timberland by ownership class and major species group, Minnesota, 1990

(In thousand cubic feet)

Ownership class	All live trees					Growing-stock trees				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
National forest	2,217,641	390,218	613,442	1,065,051	148,930	2,101,445	387,305	591,002	996,726	126,412
Bureau of Land Mgmt.	23,364	5,959	7,405	7,946	2,054	21,885	5,789	7,216	6,826	2,054
Other federal	254,560	18,401	25,207	135,892	75,060	218,397	18,035	24,016	117,292	59,054
State	2,997,887	219,111	1,082,431	1,288,583	407,762	2,714,067	211,999	1,009,845	1,149,591	342,632
County and municipal	2,999,065	223,431	619,056	1,704,133	452,445	2,733,032	216,679	576,176	1,539,670	400,507
Indian	595,043	47,929	168,807	308,129	70,178	541,409	46,785	155,425	277,447	61,752
Forest industry	738,454	89,790	230,067	344,778	73,819	670,586	86,695	214,939	306,602	62,350
Individual	6,561,652	410,061	576,985	3,320,024	2,254,582	5,542,954	395,260	542,615	2,852,523	1,752,556
Corporate	670,444	38,904	125,255	375,339	130,946	589,283	37,259	120,597	330,848	100,579
All owners	17,058,110	1,443,804	3,448,655	8,549,875	3,615,776	15,133,058	1,405,806	3,241,831	7,577,525	2,907,896

Table 19. -- Net volume of growing stock on timberland by forest type group/local type and major species group, Minnesota, 1990

(In thousand cubic feet)

Forest type group/ local type	All species	Major species group			
		Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Softwood type groups					
White-red-jack pine					
Jack pine	539,767	439,192	32,043	63,836	4,696
Red pine	527,510	430,678	27,598	61,133	8,101
White pine	128,316	90,069	14,279	22,108	1,860
Total	1,195,593	959,939	73,920	147,077	14,657
Spruce-fir					
Balsam fir	719,528	49,732	449,698	208,203	11,895
White spruce	97,370	8,434	62,880	24,420	1,636
Black spruce	760,814	31,455	657,244	70,248	1,867
Northern white-cedar	794,069	5,651	690,797	70,252	27,369
Tamarack	408,005	6,912	379,077	19,372	2,644
Total	2,779,786	102,184	2,239,696	392,495	45,411
All softwood types	3,975,379	1,062,123	2,313,616	539,572	60,068
Hardwood type groups					
Oak-hickory					
Oak-hickory	1,410,964	32,111	12,573	331,453	1,034,827
Elm-ash-cottonwood					
Elm-ash-soft maple	1,184,661	4,154	140,601	445,026	594,880
Maple-beech-birch					
Maple-basswood	1,744,185	41,761	68,989	940,803	692,632
Aspen-birch					
Aspen	5,370,673	211,127	504,811	4,239,515	415,220
Paper birch	1,050,732	51,499	146,368	768,286	84,579
Balsam poplar	389,951	2,924	53,364	308,896	24,767
Total	6,811,356	265,550	704,543	5,316,697	524,566
All hardwood types	11,151,166	343,576	926,706	7,033,979	2,846,905
Nonstocked	6,513	107	1,509	3,974	923
All forest types	15,133,058	1,405,806	3,241,831	7,577,525	2,907,896

Table 20. -- Average net annual growth of growing stock and sawtimber on timberland by Forest Survey Unit, county, and major species group, Minnesota, 1977-1989

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	(In thousand cubic feet)					*(In thousand board feet)* [1]				
Aspen-Birch Unit										
Carlton	9,167	487	1,757	5,132	1,791	24,094	2,885	5,584	12,460	3,165
Cook	11,845	1,402	3,662	5,592	1,189	44,716	6,030	18,046	18,515	2,125
Koochiching	32,438	1,729	13,662	14,565	2,482	90,630	6,950	37,857	40,206	5,617
Lake	18,532	2,847	5,691	8,037	1,957	65,749	10,683	25,003	26,281	3,782
St. Louis	60,318	6,380	18,085	31,387	4,466	221,591	34,094	63,848	115,802	7,847
Total	132,300	12,845	42,857	64,713	11,885	446,780	60,642	150,338	213,264	22,536
Northern Pine Unit										
Aitkin	22,017	1,176	3,788	10,925	6,128	67,484	4,372	10,623	35,824	16,665
Becker	8,298	742	518	3,997	3,041	34,058	4,202	1,656	18,471	9,729
Beltrami	22,639	2,878	3,679	13,080	3,002	79,424	14,167	14,523	44,438	6,296
Cass	26,897	5,609	1,840	14,018	5,430	105,285	24,644	10,416	55,172	15,053
Clearwater	9,632	971	909	6,195	1,557	32,950	4,295	3,655	21,135	3,865
Crow Wing	14,387	2,260	583	7,184	4,360	53,693	10,364	1,895	26,752	14,682
Hubbard	14,547	4,299	778	7,340	2,130	46,235	16,849	2,506	22,519	4,361
Itasca	33,945	6,056	7,482	16,492	3,915	137,776	27,484	28,358	73,005	8,929
Lake of the Woods	8,833	651	3,512	4,227	443	23,723	3,079	8,582	11,410	652
Mahnomen	2,982	78	35	1,787	1,082	10,092	694	69	6,673	2,656
Roseau	5,226	677	1,055	3,105	389	11,961	2,284	3,094	6,055	528
Wadena	4,177	2,267	130	1,143	637	11,238	5,395	278	2,861	2,704
Total	173,580	27,664	24,309	89,493	32,114	613,919	117,829	85,655	324,315	86,120
Central Hardwood Unit										
Anoka-Dakota-Ramsey-Washington	2,214	-3	21	924	1,272	6,589	111	30	1,467	4,981
Benton-Sherburne	2,408	646	8	676	1,078	9,588	2,184	77	1,875	5,452
Carver-Hennepin-Scott	1,202	-	33	591	578	5,287	-	47	1,736	3,504
Chisago-Isanti	2,452	912	32	667	841	6,100	1,185	-128	868	4,175
Douglas-Todd	858	-8	92	-628	1,402	7,625	60	682	-164	7,047
Fillmore-Olmsted	2,959	36	150	721	2,052	14,279	209	207	2,563	11,300
Goodhue	967	33	39	15	880	7,663	318	97	1,739	5,509
Houston	3,112	73	49	864	2,126	15,833	414	255	3,960	11,204
Kanabec	4,032	41	188	2,255	1,548	13,602	201	331	7,150	5,920
Le Sueur-Rice	1,149	-	39	382	728	3,088	-	34	879	2,175
Mille Lacs	3,887	40	87	2,034	1,726	12,670	-	183	6,992	5,495
Morrison	6,086	698	165	3,414	1,809	22,666	4,485	333	10,004	7,844
Otter Tail	2,954	106	67	709	2,072	16,466	643	1,127	5,517	9,179
Pine	13,398	970	820	8,721	2,887	44,103	2,983	3,204	28,678	9,238
Stearns	493	-	17	-154	630	3,484	-	264	499	2,721
Wabasha	1,277	13	-	373	891	6,929	65	-	1,463	5,401
Winona	2,795	43	19	383	2,350	14,091	290	92	1,935	11,774
Wright	599	-	-12	93	518	2,572	-	-47	438	2,181
Total	52,842	3,600	1,814	22,040	25,388	212,635	13,148	6,788	77,599	115,100

(Table 20 continued on next page)

(Table 20 continued)

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Prairie Unit	*(In thousand cubic feet)*					*(In thousand board feet)* [1]				
Blue Earth-Fairbault	772	-	133	363	276	2,378	-	275	773	1,330
Clay-Norman	552	-	-	57	495	3,897	-	-	929	2,968
Eastern Group[2]	818	-	8	148	662	4,728	-	43	917	3,768
Kandiyohi-Meeker	809	-	19	293	497	4,197	-	-	2,034	2,163
Kittson	1,036	-	-	707	329	1,206	-	-	-52	1,258
Marshall	2,376	-	181	1,797	398	3,917	-	103	2,927	887
Northern Group[3]	762	-	13	235	514	3,773	-	37	750	2,986
Pennington-Red Lake	1,190	-	-	782	408	4,155	-	-	2,365	1,790
Polk	1,460	5	-6	896	565	5,691	52	-35	3,253	2,421
Southern Group[4]	588	-	62	12	514	1,387	-	203	-563	1,747
Western Group[5]	757	46	16	12	683	3,531	222	91	-40	3,258
Total	11,120	51	426	5,302	5,341	38,860	274	717	13,293	24,576
All counties	369,842	44,160	69,406	181,548	74,728	1,312,194	191,893	243,498	628,471	248,332

[1]International 1/4-inch rule.

[2]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[3]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[4]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[5]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 21. -- Average annual removals of growing stock and sawtimber on timberland by Forest Survey Unit, county, and major species group, Minnesota 1977-1989

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	(In thousand cubic feet)					*(In thousand board feet)* [1]				
Aspen-Birch Unit										
Carlton	3,658	185	531	2,359	583	5,991	878	1,185	3,370	558
Cook	9,280	3,026	3,356	2,831	67	26,644	13,373	5,944	7,327	-
Koochiching	25,122	2,100	8,429	13,920	673	53,652	6,647	18,710	26,992	1,303
Lake	10,881	370	3,306	6,916	289	20,546	1,825	5,484	12,921	316
St. Louis	33,416	4,047	6,839	21,241	1,289	72,348	19,032	13,014	38,832	1,470
Total	82,357	9,728	22,461	47,267	2,901	179,181	41,755	44,337	89,442	3,647
Northern Pine Unit										
Aitkin	6,774	101	691	4,975	1,007	19,126	418	1,689	14,037	2,982
Becker	3,026	662	149	1,691	524	8,026	2,830	506	3,343	1,347
Beltrami	14,202	3,362	1,948	8,479	413	37,854	13,266	4,078	19,978	532
Cass	15,224	2,091	1,446	10,317	1,370	33,265	7,509	3,873	19,335	2,548
Clearwater	3,763	406	346	2,869	142	8,446	2,010	1,105	4,776	555
Crow Wing	6,536	1,035	9	3,742	1,750	15,457	3,525	46	8,910	2,976
Hubbard	7,224	1,554	287	5,084	299	14,741	6,647	468	7,122	504
Itasca	28,565	1,369	4,927	20,683	1,586	69,465	6,426	13,364	47,793	1,882
Lake of the Woods	2,090	599	80	1,411	-	5,493	1,537	230	3,726	-
Mahnomen	1,117	98	24	673	322	2,592	390	132	1,238	832
Roseau	833	401	83	209	140	2,284	1,836	315	133	-
Wadena	1,396	516	53	712	115	3,630	1,778	248	1,465	139
Total	90,750	12,194	10,043	60,845	7,668	220,379	48,172	26,054	131,856	14,297
Central Hardwood Unit										
Anoka-Dakota-Ramsey-Washington	287	-	-	39	248	671	-	-	119	552
Benton-Sherburne	736	53	-	261	422	2,371	-	-	986	1,385
Carver-Hennepin-Scott	51	-	-	35	16	163	-	-	163	-
Chisago-Isanti	1,130	136	-	473	521	4,275	747	-	1,495	2,033
Douglas-Todd	888	39	14	645	190	2,944	102	73	2,220	549
Fillmore-Olmsted	1,868	-	-	575	1,293	8,737	-	-	2,559	6,178
Goodhue	1,796	-	-	1,031	765	7,016	-	-	3,914	3,102
Houston	1,779	-	-	123	1,656	8,118	-	-	444	7,674
Kanabec	2,018	-	-	1,408	610	4,849	-	-	2,875	1,974
Le Sueur-Rice	443	-	-	363	80	1,101	-	-	698	403
Mille Lacs	1,329	-	-	898	431	2,923	-	-	1,805	1,118
Morrison	3,180	24	-	2,121	1,035	7,795	-	-	4,082	3,713
Otter Tail	3,607	-	-	2,027	1,580	10,157	-	-	5,692	4,465
Pine	5,486	130	75	4,045	1,236	13,390	408	261	8,193	4,528
Stearns	664	-	-	391	273	2,254	-	-	1,207	1,047
Wabasha	1,255	-	-	600	655	5,803	-	-	2,758	3,045
Winona	2,735	-	-	231	2,504	12,887	-	-	1,098	11,789
Wright	508	-	-	405	103	1,502	-	-	1,185	317
Total	29,760	382	89	15,671	13,618	96,956	1,257	334	41,493	53,872

(Table 21 continued on next page)

(Table 21 continued)

Forest Survey Unit and county	Growing stock					Sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
Prairie Unit	*(In thousand cubic feet)*					*(In thousand board feet)* [1]				
Blue Earth-Fairbault	143	-	-	95	48	555	-	-	353	202
Clay-Norman	1,136	-	-	471	665	3,530	-	-	1,485	2,045
Eastern Group[2]	595	-	-	159	436	2,322	-	-	591	1,731
Kandiyohi-Meeker	15	-	-	15	-	84	-	-	84	-
Kittson	159	-	-	151	8	49	-	-	49	-
Marshall	1,325	-	22	1,024	279	1,126	-	-	587	539
Northern Group[3]	486	-	-	288	198	2,065	-	-	1,111	954
Pennington-Red Lake	467	-	-	353	114	857	-	-	574	283
Polk	2,268	-	-	1,726	542	5,809	-	-	3,830	1,979
Southern Group[4]	120	-	-	77	43	394	-	-	256	138
Western Group[5]	481	-	-	195	286	2,043	-	-	699	1,344
Total	7,195	-	22	4,554	2,619	18,834	-	-	9,619	9,215
All counties	210,062	22,304	32,615	128,337	26,806	515,350	91,184	70,725	272,410	81,031

[1]International 1/4-inch rule.

[2]Includes: Dodge, Freeborn, Mower, Steele, and Waseca counties.

[3]Includes: McLeod, Nicollet, Renville, and Sibley counties.

[4]Includes: Brown, Cottonwood, Jackson, Martin, Redwood, and Watonwan counties.

[5]Includes: Big Stone, Chippewa, Grant, Lac qui Parle, Lincoln, Lyon, Murray, Nobles, Pipestone, Pope, Rock, Stevens, Swift, Traverse, Wilkin, and Yellow Medicine counties.

Table 22. -- Average net annual growth and average annual removals of growing stock and sawtimber on timberland by species group, Minnesota, 1977-1989

Species group	Growing stock		Sawtimber	
	Average net annual growth	Average annual removals	Average net annual growth	Average annual removals
Softwoods	*(In thousand cubic feet)*		*(In thousand board feet)* [1]	
Jack pine	11,258	11,827	48,505	40,566
Red pine	23,874	5,246	94,000	24,373
White pine	8,838	5,231	48,421	26,245
White spruce	12,913	4,681	52,414	21,668
Black spruce	11,506	9,651	24,506	11,222
Balsam fir	17,211	13,731	65,840	26,413
Tamarack	12,375	2,126	38,135	4,488
Eastern redcedar	649	-	1,433	-
Northern white-cedar	14,752	2,426	61,170	6,934
Other softwoods	190	-	967	-
Total softwoods	113,566	54,919	435,391	161,909
Hardwoods				
Select white oak	15,014	5,608	58,803	17,307
Select red oak	18,005	11,659	91,792	42,908
Other red oak	417	352	3,470	1,177
Select hickory	448	19	1,512	83
Other hickory	419	32	615	80
Basswood	17,657	5,311	59,232	16,100
Yellow birch	104	32	1,041	-
Hard maple	12,429	2,950	25,189	7,177
Soft maple	15,083	1,777	21,546	1,908
Elm	-11,720	7,437	-42,458	25,571
Black ash	18,684	4,396	39,200	7,127
White & green ash	6,926	1,382	22,681	4,304
Cottonwood	1,205	224	6,717	1,103
Willow	506	259	2,918	763
Hackberry	406	8	531	-
Balsam poplar	9,382	8,227	30,614	15,584
Bigtooth aspen	8,489	3,985	39,376	7,943
Quaking aspen	115,726	81,855	443,100	183,804
Paper birch	23,714	18,913	62,209	18,761
River birch	3	10	-	-
Black cherry	409	250	1,506	447
Black walnut	465	74	1,685	322
Butternut	689	91	3,131	426
Other hardwoods	1,816	292	2,393	546
Total hardwoods	256,276	155,143	876,803	353,441
All species	369,842	210,062	1,312,194	515,350

[1] International 1/4-inch rule.

Table 23. -- Average annual mortality of growing stock and sawtimber on timberland by species group, Minnesota, 1977-1989

Species group	Growing stock average annual mortality	Sawtimber average annual mortality
Softwoods	*(In thousand cubic feet)*	*(In thousand board feet)* [1]
Jack pine	10,340	33,897
Red pine	386	2,009
White pine	992	5,500
White spruce	2,053	8,568
Black spruce	14,078	15,744
Balsam fir	32,256	62,000
Tamarack	4,454	7,678
Eastern redcedar	30	52
Northern white-cedar	1,829	7,145
Total softwoods	66,418	142,593
Hardwoods		
Select white oak	1,004	3,359
Select red oak	7,015	18,511
Other red oak	480	1,254
Select hickory	48	85
Other hickory	39	117
Basswood	3,118	8,898
Yellow birch	278	862
Hard maple	1,074	2,580
Soft maple	2,226	2,073
Elm	27,087	77,010
Black ash	3,800	6,127
White & green ash	525	1,010
Cottonwood	332	1,181
Willow	351	1,035
Hackberry	92	348
Balsam poplar	14,955	30,426
Bigtooth aspen	2,605	5,180
Quaking aspen	67,211	132,963
Paper birch	21,010	20,615
Black cherry	132	178
Black walnut	20	132
Butternut	104	138
Other hardwoods	876	1,350
Total hardwoods	154,382	315,432
All species	220,800	458,025

[1]International 1/4-inch rule.

Table 24. -- Average net annual growth and average annual removals of growing stock and sawtimber on timberland by ownership class and major species group, Minnesota, 1977-1989

Ownership class	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	Average annual growth of growing stock				
		Major species group			
	(In thousand cubic feet)				
National forest	49,949	11,576	11,713	23,075	3,585
Bureau of Land Mgmt.	428	88	215	60	65
Other federal	4,534	498	607	2,043	1,386
State	64,046	6,385	19,818	29,210	8,633
County and municipal	66,984	6,490	11,654	37,018	11,822
Indian	12,044	1,385	2,831	6,079	1,749
Forest industry	18,988	3,829	4,723	8,937	1,499
Individual	137,652	12,618	14,945	66,935	43,154
Corporate	15,217	1,291	2,900	8,191	2,835
All owners	369,842	44,160	69,406	181,548	74,728
	Average annual removals of growing stock				
		Major species group			
	(In thousand cubic feet)				
National forest	36,371	4,923	7,963	22,503	982
Bureau of Land Mgmt.	189	180	-	9	-
Other federal	1,156	203	283	606	64
State	33,016	4,828	8,551	18,041	1,596
County and municipal	37,866	3,720	4,799	26,768	2,579
Indian	3,543	1,347	688	1,366	142
Forest industry	18,664	1,639	4,041	11,721	1,263
Individual	67,548	4,385	3,871	39,992	19,300
Corporate	11,709	1,079	2,419	7,331	880
All owners	210,062	22,304	32,615	128,337	26,806
	Average net annual growth of sawtimber				
		Major species group			
	(In thousand board feet) [1]				
National forest	205,532	54,662	53,154	89,114	8,602
Bureau of Land Mgmt.	2,294	891	563	699	141
Other federal	20,430	2,501	1,689	10,478	5,762
State	203,882	26,255	56,946	94,432	26,249
County and municipal	235,112	28,891	41,422	135,955	28,844
Indian	41,954	6,425	9,479	22,490	3,560
Forest industry	59,476	12,284	16,193	27,811	3,188
Individual	489,158	52,959	53,560	219,220	163,419
Corporate	54,356	7,025	10,492	28,272	8,567
All owners	1,312,194	191,893	243,498	628,471	248,332
	Average annual removals of sawtimber				
		Major species group			
	(In thousand board feet) [1]				
National forest	83,545	21,883	17,082	43,739	841
Bureau of Land Mgmt.	641	641	-	-	-
Other federal	3,430	1,001	470	1,656	303
State	79,074	19,165	19,776	37,374	2,759
County and municipal	87,346	15,184	10,679	55,854	5,629
Indian	9,684	6,176	1,112	2,005	391
Forest industry	38,205	4,998	8,298	23,103	1,806
Individual	187,179	17,627	9,523	92,923	67,106
Corporate	26,246	4,509	3,785	15,756	2,196
All owners	515,350	91,184	70,725	272,410	81,031

[1]International 1/4-inch rule.

Table 25. -- Average net annual growth and average annual removals of growing stock and sawtimber on timberland by forest type group/local type and major species group, Minnesota 1977-1989

Forest type group/ local type	Average net annual growth of growing stock					Average annual removals of growing stock				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	(In thousand cubic feet)					(In thousand cubic feet)				
Softwood type groups										
White-red-jack pine										
Jack pine	13,805	10,452	1,047	2,139	167	5,915	3,856	1,196	820	43
Red pine	21,344	18,278	932	1,844	290	11,450	7,748	539	2,685	478
White pine	3,225	2,650	224	314	37	1,472	578	289	594	11
Total	38,374	31,380	2,203	4,297	494	18,837	12,182	2,024	4,099	532
Spruce-fir										
Balsam fir	16,035	1,312	10,111	4,219	393	3,819	171	2,143	1,505	-
White spruce	4,071	452	2,731	826	62	3,544	90	368	2,964	122
Black spruce	16,197	663	13,658	1,838	38	5,265	353	4,664	231	17
Northern white-cedar	8,286	81	8,230	-166	141	1,884	34	1,575	240	35
Tamarack	10,563	228	9,647	509	179	2,669	26	2,607	36	-
Total	55,152	2,736	44,377	7,226	813	17,181	674	11,357	4,976	174
All softwood types	93,526	34,116	46,580	11,523	1,307	36,018	12,856	13,381	9,075	706
Hardwood type groups										
Oak-hickory										
Oak-hickory	29,825	806	582	6,235	22,202	11,215	300	266	2,553	8,096
Elm-ash-cottonwood										
Elm-ash-soft maple	18,006	33	1,386	977	15,610	12,017	75	1,185	6,927	3,830
Maple-beech-birch										
Maple-basswood	32,273	1,287	525	12,783	17,678	20,532	603	1,216	10,988	7,725
Aspen-birch										
Aspen	165,101	6,325	16,530	127,935	14,311	118,678	7,906	13,773	91,196	5,803
Paper birch	21,995	1,408	3,001	14,955	2,631	7,046	253	2,011	4,233	549
Balsam poplar	8,934	150	751	7,089	944	4,065	55	783	3,130	97
Total	196,030	7,883	20,282	149,979	17,886	129,789	8,214	16,567	98,559	6,449
All hardwood types	276,134	10,009	22,775	169,974	73,376	173,553	9,192	19,234	119,027	26,100
Nonstocked	182	35	51	51	45	491	256	-	235	-
All forest types	369,842	44,160	69,406	181,548	74,728	210,062	22,304	32,615	128,337	26,806

Forest type group/ local type	Average net annual growth of sawtimber					Average annual removals of sawtimber				
		Major species group					Major species group			
	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods
	(In thousand board feet) [1]					(In thousand board feet) [1]				
Softwood type groups										
White-red-jack pine										
Jack pine	53,635	43,851	4,537	4,914	333	14,547	11,718	1,884	945	-
Red pine	77,689	69,468	2,883	4,900	438	35,878	31,269	800	2,886	923
White pine	17,160	14,531	1,122	1,369	138	3,944	3,139	252	499	54
Total	148,484	127,850	8,542	11,183	909	54,369	46,126	2,936	4,330	977
Spruce-fir										
Balsam fir	58,464	6,010	38,158	13,527	769	7,971	860	4,353	2,758	-
White spruce	11,530	1,819	7,321	2,317	73	7,605	347	880	6,329	49
Black spruce	32,897	2,061	26,072	4,691	73	6,646	1,768	4,328	550	-
Northern white-cedar	39,250	516	38,706	-131	159	4,490	205	3,281	975	29
Tamarack	30,710	953	27,533	2,007	217	4,855	98	4,625	132	-
Total	172,851	11,359	137,790	22,411	1,291	31,567	3,278	17,467	10,744	78
All softwood types	321,335	139,209	146,332	33,594	2,200	85,936	49,404	20,403	15,074	1,055
Hardwood type groups										
Oak-hickory										
Oak-hickory	137,997	4,565	1,636	25,147	106,649	38,595	1,360	1,378	6,777	29,080
Elm-ash-cottonwood										
Elm-ash-soft maple	61,110	284	9,521	12,762	38,543	32,013	396	3,867	18,648	9,102
Maple-beech-birch										
Maple-basswood	118,252	7,521	2,861	49,012	58,858	71,969	3,264	3,871	35,419	29,415
Aspen-birch										
Aspen	577,479	32,657	65,754	444,888	34,180	262,042	34,547	33,796	182,838	10,861
Paper birch	69,019	6,913	12,360	43,439	6,307	13,695	1,320	5,188	5,902	1,285
Balsam poplar	26,049	557	4,774	19,197	1,521	9,944	252	2,222	7,237	233
Total	672,547	40,127	82,888	507,524	42,008	285,681	36,119	41,206	195,977	12,379
All hardwood types	989,906	52,497	96,906	594,445	246,058	428,258	41,139	50,322	256,821	79,976
	953	187	260	432	74	1,156	641	-	515	-
All forest types	1,312,194	191,893	243,498	628,471	248,332	515,350	91,184	70,725	272,410	81,031

[1]International 1/4-inch rule.

Table 26. -- All live aboveground tree biomass on timberland by ownership class, major species group, and tree biomass component, Minnesota, 1990

(In green tons)

Ownership class and major species group	All components	Tree biomass component						
		All live 1-5 inch trees	Growing-stock trees			Nongrowing-stock trees		
			Stumps	Boles	Tops and limbs	Stumps	Boles	Tops and limbs
National forest								
Pine	13,578,765	1,009,901	677,253	10,565,937	1,184,922	7,825	119,652	13,275
Other softwoods	30,568,900	8,126,204	1,592,603	15,189,248	4,487,635	99,943	850,371	222,896
Soft hardwoods	54,104,960	6,372,412	2,152,745	31,480,991	9,117,541	242,653	3,731,514	1,007,104
Hard hardwoods	9,936,805	1,865,840	398,223	4,457,360	1,504,734	94,223	1,250,092	366,333
Total	108,189,430	17,374,357	4,820,824	61,693,536	16,294,832	444,644	5,951,629	1,609,608
Bureau of Land Mgmt.								
Pine	197,312	1,080	10,866	159,035	18,447	535	6,535	814
Other softwoods	528,578	268,538	21,356	176,534	53,341	657	7,070	1,082
Soft hardwoods	388,092	25,551	13,416	216,077	57,429	3,516	58,529	13,574
Hard hardwoods	112,704	18,171	6,617	64,470	23,446	-	-	-
Total	1,226,686	313,340	52,255	616,116	152,663	4,708	72,134	15,470
Other federal								
Pine	631,205	34,000	30,167	491,590	53,806	1,130	18,535	1,977
Other softwoods	1,332,196	423,570	66,432	616,972	164,268	4,622	44,621	11,711
Soft hardwoods	6,778,572	644,640	255,722	3,679,477	1,040,859	57,447	876,395	224,032
Hard hardwoods	4,303,473	243,842	188,797	2,127,254	678,399	63,950	781,275	219,956
Total	13,045,446	1,346,052	541,118	6,915,293	1,937,332	127,149	1,720,826	457,676
State								
Pine	7,902,650	739,096	391,783	5,799,748	667,451	18,194	256,808	29,570
Other softwoods	61,928,660	22,351,494	2,831,331	26,046,550	7,084,821	322,619	2,600,176	691,669
Soft hardwoods	67,309,197	9,122,259	2,510,841	36,189,064	10,576,430	439,246	6,673,080	1,798,277
Hard hardwoods	24,769,039	3,603,208	1,069,510	11,883,953	3,911,496	259,848	3,084,708	956,316
Total	161,909,546	35,816,057	6,803,465	79,919,315	22,240,198	1,039,907	12,614,772	3,475,832
County and municipal								
Pine	7,898,393	627,752	385,664	5,925,881	669,793	16,996	244,224	28,083
Other softwoods	32,923,640	9,913,109	1,577,411	15,086,484	4,266,491	174,536	1,517,768	387,841
Soft hardwoods	86,091,848	9,286,677	3,308,105	48,407,060	14,166,351	533,601	8,167,874	2,222,180
Hard hardwoods	27,854,263	4,300,238	1,284,139	13,857,977	4,724,690	217,045	2,633,243	836,931
Total	154,768,144	24,127,776	6,555,319	83,277,402	23,827,325	942,178	12,563,109	3,475,035

(Table 26 continued on next page)

(Table 26 continued)

Ownership class and major species group	All components	Tree biomass component						
		All live 1-5 inch trees	Growing-stock trees			Nongrowing-stock trees		
			Stumps	Boles	Tops and limbs	Stumps	Boles	Tops and limbs
Indian								
Pine	1,627,003	75,460	81,261	1,274,464	142,126	3,643	44,665	5,384
Other softwoods	8,360,320	2,397,749	443,402	3,867,422	1,034,685	55,383	446,487	115,192
Soft hardwoods	15,539,548	1,665,315	592,249	8,685,637	2,501,959	99,543	1,581,179	413,666
Hard hardwoods	4,475,222	766,119	203,095	2,110,656	728,900	37,744	479,482	149,226
Total	30,002,093	4,904,643	1,320,007	15,938,179	4,407,670	196,313	2,551,813	683,468
Forest industry								
Pine	3,621,088	654,798	173,439	2,375,563	282,980	8,322	112,573	13,413
Other softwoods	11,521,198	3,218,498	590,280	5,389,476	1,595,402	63,896	521,666	141,980
Soft hardwoods	19,031,992	3,333,215	654,012	9,664,304	2,838,374	123,253	1,887,916	530,918
Hard hardwoods	4,822,599	1,068,724	199,833	2,034,895	712,400	47,892	574,073	184,782
Total	38,996,877	8,275,235	1,617,564	19,464,238	5,429,156	243,363	3,096,228	871,093
Individual								
Pine	14,428,147	1,002,726	729,441	10,813,424	1,253,269	36,407	528,823	64,057
Other softwoods	29,699,049	8,233,236	1,437,169	14,548,280	3,818,713	134,366	1,215,174	312,111
Soft hardwoods	168,190,990	19,181,448	6,310,082	88,441,021	25,800,142	1,453,621	21,263,400	5,741,276
Hard hardwoods	129,786,088	12,003,911	5,420,910	62,368,465	19,550,255	1,802,335	22,188,040	6,452,172
Total	342,104,274	40,421,321	13,897,602	176,171,190	50,422,379	3,426,729	45,195,437	12,569,616
Corporate								
Pine	1,414,639	145,255	66,626	1,015,003	116,245	4,949	57,582	8,979
Other softwoods	6,421,580	1,784,217	328,763	3,168,133	913,920	18,393	165,488	42,666
Soft hardwoods	19,501,575	2,418,859	738,281	10,438,393	3,086,443	140,333	2,115,561	563,705
Hard hardwoods	7,911,433	957,562	318,192	3,543,346	1,160,871	113,279	1,397,583	420,600
Total	35,249,227	5,305,893	1,451,862	18,164,875	5,277,479	276,954	3,736,214	1,035,950
All ownerships								
Pine	51,299,202	4,290,068	2,546,500	38,420,645	4,389,039	98,001	1,389,397	165,552
Other softwoods	183,284,121	56,716,615	8,888,747	84,089,099	23,419,276	874,415	7,368,821	1,927,148
Soft hardwoods	436,936,774	52,050,376	16,535,453	237,202,024	69,185,528	3,093,213	46,355,448	12,514,732
Hard hardwoods	213,971,626	24,827,615	9,089,316	102,448,376	32,995,191	2,636,316	32,388,496	9,586,316
Total	885,491,723	137,884,674	37,060,016	462,160,144	129,989,034	6,701,945	87,502,162	24,193,748

Table 27.-- Removals[1], net annual growth, and inventory of growing stock on timberland, Minnesota, 1990, and low removals option projections [2] to 2020

(In million cubic feet)

Year	Removals			Growth			Inventory		
	All species	Softwoods	Hardwoods	All species	Softwoods	Hardwoods	All species	Softwoods	Hardwoods
1990	260.3	63.2	197.1	440.1	125.5	314.6	15,133.1	4,647.7	10,485.4
2000	287.7	71.0	216.7	486.9	141.0	345.9	16,751.3	5,222.4	11,528.9
2010	318.0	79.8	238.2	538.6	158.4	380.2	18,539.5	5,866.7	12,672.8
2020	351.4	89.6	261.8	595.7	177.9	417.8	20,514.7	6,588.6	13,926.1

[1] Timber removals include volume "lost" due to land clearing, flooding, thinning, or changes in land use, in addition to timber cut and used.

[2] Based on the following assumptions: (a) that the area of timberland will decline from 14,723 to 14,000 thousand acres between 1990 and 2020; (b) that growth rates for softwoods and hardwoods will remain constant at the 1989 level over the projection period; and (c) that removals rates for softwoods and hardwoods will remain constant at the 1988 level.

Table 28--Removals[1], net annual growth, and inventory of growing stock on timberland, Minnesota, 1990, and high removals option projections [2] to 2020

(In million cubic feet)

Year	Removals			Growth			Inventory		
	All species	Softwoods	Hardwoods	All species	Softwoods	Hardwoods	All species	Softwoods	Hardwoods
1990	264.9	64.6	200.3	440.1	125.5	314.6	15,133.1	4,647.7	10,485.4
2000	337.5	86.8	250.7	479.0	138.7	340.3	16,480.1	5,138.0	11,342.1
2010	408.5	109.7	298.8	506.0	148.8	357.2	17,418.2	5,512.4	11,905.8
2020	472.2	131.4	340.8	518.8	155.0	363.8	17,865.4	5,738.9	12,126.5

[1] Timber removals include volume "lost" due to land clearing, flooding, thinning, or changes in land use, in addition to timber cut and used.

[2] Based on the following assumptions: (a) that the area of timberland will decline from 14,723 to 14,000 thousand acres between 1990 and 2020; (b) that growth rates for softwoods and hardwoods will remain constant at the 1989 level over the projection period; and (c) that removal rates for softwoods and hardwoods will be greater than those used for the low removals option.

Table 29. -- Sampling errors[1] for Forest Survey Unit and county totals of area of timberland, volume, average net annual growth, and average annual removals on timberland, Minnesota, 1990

(Sampling error in percent)

Forest Survey Unit and county	Area of timberland	Growing stock			Sawtimber		
		Volume	Average net annual growth	Average annual removals	Volume	Average net annual growth	Average annual removals
Aspen-Birch Unit							
Carlton	2.37	4.56	7.14	47.83	7.59	9.52	77.77
Cook	1.84	3.07	6.28	30.03	4.52	6.99	36.88
Koochiching	1.16	2.28	3.80	18.25	3.81	4.91	25.99
Lake	1.50	2.79	5.02	27.73	4.28	5.76	41.99
St. Louis	0.84	1.62	2.78	15.82	2.50	3.14	22.38
Total	0.57	1.08	1.88	10.08	1.69	2.21	14.22
Northern Pine Unit							
Aitkin	1.43	2.87	4.35	20.17	4.14	5.25	18.36
Becker	2.07	3.88	7.09	30.17	5.41	7.39	28.35
Beltrami	1.31	2.63	4.29	13.93	3.79	4.84	13.05
Cass	1.30	2.44	3.94	13.45	3.35	4.20	13.92
Clearwater	2.24	4.25	6.58	27.06	6.14	7.51	27.63
Crow Wing	1.92	3.64	5.38	20.53	5.17	5.88	20.43
Hubbard	1.89	3.73	5.35	19.53	5.48	6.34	20.92
Itasca	1.04	2.09	3.51	9.82	2.85	3.67	9.64
Lake of the Woods	1.91	4.55	6.87	36.31	7.27	8.85	34.27
Mahnomen	3.57	6.79	11.83	49.66	10.61	13.57	49.88
Roseau	2.56	6.28	8.93	57.51	9.42	12.47	53.14
Wadena	3.46	8.17	9.99	44.43	12.03	12.86	42.15
Total	0.49	0.98	1.55	5.51	1.39	1.74	5.41
Central Hardwood Unit							
Anoka	8.29	21.67	35.98	-	27.46	47.83	-
Benton	8.23	23.26	44.76	105.56	28.61	45.04	108.34
Carver	11.07	29.49	51.82	-	36.74	51.79	-
Chisago	6.96	16.77	44.67	56.67	20.88	39.64	57.25
Dakota	13.77	31.58	89.91	106.11	38.48	75.97	138.72
Douglas	8.63	17.05	78.27	568.44	19.39	48.84	-
Fillmore	4.88	10.33	27.14	51.09	11.69	23.36	46.99
Goodhue	5.85	11.47	40.58	42.42	13.10	27.50	42.90
Hennepin	14.30	25.80	67.46	-	27.86	52.77	-
Houston	4.19	8.97	22.62	42.62	10.48	19.13	39.88
Isanti	6.66	16.44	31.03	161.43	26.22	49.00	196.32
Kanabec	4.10	9.65	19.87	40.02	13.87	20.64	51.60
Le Sueur	10.27	20.71	60.51	85.40	22.36	60.35	108.29
Mille Lacs	4.12	9.25	20.24	49.31	13.70	21.38	66.46
Morrison	3.76	7.89	16.18	31.88	11.47	15.99	40.70
Olmsted	7.60	16.05	44.73	71.62	20.35	39.78	66.85
Otter Tail	3.36	7.84	23.22	29.93	10.31	18.76	35.65
Pine	2.20	5.16	10.90	24.27	8.02	11.46	31.05
Ramsey	-	-	-	-	-	-	-
Rice	10.90	24.44	47.23	-	28.66	62.21	-
Scott	12.87	29.90	78.42	251.71	32.10	74.43	281.45
Sherburne	6.81	15.89	31.42	85.12	22.61	29.34	100.79
Stearns	5.83	14.13	56.84	69.76	17.94	40.78	75.69
Todd	4.94	11.93	51.61	60.66	15.55	33.39	66.23
Wabasha	5.89	12.85	35.32	50.74	15.39	28.92	47.17
Washington	9.94	22.75	44.99	-	27.51	43.57	-
Winona	4.31	8.85	23.87	34.37	10.24	20.28	31.65
Wright	7.37	17.45	51.56	79.75	19.87	47.46	92.72
Total	1.02	2.30	5.49	10.42	3.01	5.22	11.54

(Table 29 continued on next page)

(Table 29 continued)

Forest Survey Unit and county	Area of timberland	Growing stock			Sawtimber		
		Volume	Average net annual growth	Average annual removals	Volume	Average net annual growth	Average annual removals
Prairie Unit	34.46	66.25	95.62	-	107.90	165.31	-
Big Stone	10.06	17.03	47.59	131.32	20.30	71.46	114.55
Blue Earth	16.49	25.45	57.40	374.51	31.06	164.90	307.06
Brown	19.47	37.72	59.54	-	49.61	89.69	-
Chippewa	12.56	19.07	62.06	53.54	25.76	49.38	54.80
Clay	26.70	87.76	87.09	-	110.08	182.66	-
Cottonwood	21.24	34.33	71.20	76.24	41.54	65.08	64.07
Dodge	17.76	31.62	53.64	316.52	35.03	64.36	356.27
Fairbault	19.47	24.85	81.86	309.24	27.17	72.04	270.80
Freeborn	25.23	37.10	-	98.92	45.49	124.65	78.83
Grant	36.33	39.66	122.69	-	42.46	134.42	-
Jackson	13.00	20.35	49.03	-	23.40	51.87	-
Kandiyohi	7.40	14.97	30.73	115.03	30.93	67.15	367.01
Kittson	22.56	52.71	264.36	458.68	68.13	-	359.74
Lac qui Parle	-	-	-	-	-	-	-
Lincoln	38.53	38.46	84.20	512.82	47.75	82.92	422.35
Lyon	20.48	38.21	164.86	155.51	42.10	105.14	126.26
McLeod	5.17	11.26	20.29	39.85	22.42	37.26	76.56
Marshall	29.85	86.38	126.65	264.82	108.44	162.48	300.69
Martin	13.06	21.56	49.33	374.51	25.22	49.99	280.31
Meeker	22.73	42.99	93.46	192.12	50.25	82.92	163.14
Mower	31.46	43.50	93.05	-	47.89	87.95	-
Murray	15.57	21.70	56.27	88.44	26.09	63.54	76.06
Nicollet	-	-	-	-	-	-	-
Nobles	11.75	19.85	57.30	72.34	26.44	57.12	70.39
Norman	10.12	17.74	32.11	86.53	29.86	46.35	108.37
Pennington	54.49	71.95	193.99	-	86.71	138.14	-
Pipestone	7.80	11.88	25.89	30.46	17.15	30.91	33.71
Polk	16.95	29.92	88.12	152.89	36.50	84.54	146.15
Pope	11.42	23.86	63.72	106.35	39.32	57.87	149.58
Red Lake	19.47	27.08	110.59	167.49	31.22	98.46	162.16
Redwood	22.73	28.17	125.62	-	32.32	91.19	-
Renville	-	-	-	-	-	-	-
Rock	13.73	21.24	52.50	127.22	24.63	65.18	113.76
Sibley	19.47	43.04	90.67	116.88	50.54	115.74	132.49
Steele	34.46	102.95	150.84	-	170.24	153.44	-
Stevens	40.25	87.87	190.36	248.76	112.15	164.49	228.87
Swift	-	-	-	-	-	-	-
Traverse	17.38	23.88	62.81	-	26.84	67.35	-
Waseca	40.25	85.09	-	-	92.13	-	-
Watonwan	-	-	-	-	-	-	-
Wilkin	32.86	63.64	-	130.26	69.32	-	120.05
Yellow Medicine	2.36	4.11	9.38	17.10	5.53	11.83	18.72
Total	0.36	0.71	1.30	4.86	1.02	1.45	6.03
All counties							

[1]Sampling error is not calculated when the estimated area, volume, or removals for a county is equal to 0, or growth is less than or equal to 0.

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The fifth Minnesota forest inventory found 16.7 million acres of forest land in 1990, of which 14.7 million acres is timberland. Growing-stock volume on timberland increased from 12.4 to 15.1 billion cubic feet between 1977 and 1990, a gain of 22 percent. Analysis and statistics on forest area, timber volume, growth, removals, mortality, and projections are presented.

KEY WORDS: Timberland area, volume, growth, removals, mortality.

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Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.